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Technology, Trade, and the U.S. Residential Construction Industry

Special Report

CONGRESS OF THE UNITED STATES
Office of Technology Assessment
Washington, D. C. 20510

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Foreword

New technologies, and the expansion of international trade, have created a new framework for the U.S. economy. Within this broad setting, America's residential construction industry is changing as well. Technology has affected both building techniques and the nature of the home itself. Specifically, factory-based production allows for greater use of advanced automation, and a wide range of technologies that improve comfort while reducing energy costs are now available.

Recently, many U.S. home producers have become vulnerable to foreign competition, as factory-based construction techniques have improved rapidly in several other countries. The combination of an antiquated regulatory system and a lack of industry incentives for research has impeded America's ability to upgrade housing quality, and to hold its own against aggressive and sophisticated overseas builders.

This special report is part of a larger OTA project that analyzes the effects of technological change on the structure of the domestic economy, on international trade, and on options for public policy. Home construction's importance to the study stems from the fact that although housing accounts for over 27 percent of personal spending, ownership of attractive residences remains beyond the reach of many American families. The quality and cost of the factory-built home, and the number of jobs generated by the industry, will be strongly influenced by whether the United States takes full advantage of developing technology.

The House Banking Committee requested that OTA expand its analysis to include regulatory alternatives that might encourage the research and development of new technologies. Pressures to revise currently decentralized and fragmented U.S. housing policies have risen over the last several years. Coordination of State and local building codes, and Federal standards established by the Department of Housing and Urban Development, will change along with the changing structure of the industry. We trust that this special report will help Congress to recognize how existing statutes may operate in a new environment, and to update these guidelines if necessary.

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Chapter 1

Technology, Trade, and the Future of the U.S. Housing Construction Industry

Chapter 1

Technology, Trade, and the Future of the U.S. Housing Construction Industry

While technical change in the U.S. construction industry has proceeded more slowly than forecasters once predicted, the past two decades have witnessed significant progress in the technology of the house itself, and in that of the appliances installed. These improvements have made structures easier and less expensive to build, and reduce energy and other operating costs. New equipment and housing designs can make interior spaces more comfortable, can permit greater control over the quality of indoor air, and can offer a variety of other amenities. New information technologies can integrate the network of diverse firms involved in construction. Such innovations can make it easier for prospective homeowners to find housing commensurate with their individual tastes, and may even allow them to participate in the design of the house to be purchased.

Has the U.S. housing industry taken adequate advantage of technologies that have improved quality and reduced costs in other industries? Might a shift to modern production technology reshape the domestic housing industry, change economies of scale and scope for individual businesses, and affect the number and nature of the jobs offered by the industry? If the industry comes to resemble other U.S. manufacturing industries, the potential for international trade in construction increases; how will the domestic industry fare against competition from sophisticated foreign producers of housing components and production equipment?

This report explores these questions in order to determine whether changes in public policy may be needed to keep pace with technical change, particularly for smaller residential units. As home building comes to resemble other manufacturing industries, and as it grows from a local enterprise to one with regional, national, and international concerns, it is necessary to consider whether policies regulating home production should be commensurate with regulations that guide other types of factory production. Programs to subsidize home purchases, to conduct technical research, to establish fire and safety regulations and government procurement, and more, have a significant effect on the housing that reaches the American public. At present, however, housing policy in the United States is fragmented and lacks central coordination. It does not respond to the changing needs of the housing construction industry.

Technical change in the U.S. housing industry has not taken the form of a revolutionary shift from craft-based field erection techniques to factory-based production. Change has instead followed a complex and diverse course that is virtually impossible to document with precision. Most new homes built in the United States today use prehung windows and doors, and factory-made roof trusses or floor joists. Wall panels and large three-dimensional modules are shipped to construction sites and assembled rapidly. Traditional "manufactured" (mobile) homes are constructed in factories that operate with improved production equipment. While statistics are confusing and often contradictory, it appears 10 to 35 percent of all new single-family homes built in the United States were constructed in factories—25 to 50 percent, if "manufactured" (mobile) homes are included. In many cases, however, the "factory" construction techniques used in the United States do not take advantage of the mass-production devices employed in the manufacture of products ranging from toasters to automobiles. These housing factories typically employ semiskilled workers in facilities where capital investments per worker fall below the standards of other production industries.

A number of foreign firms have moved aggressively into the business of producing housing components. Imported homes and joint ventures with foreign housing producers already exist in Texas, Florida, Massachusetts, Maine, New York, Rhode Island, Michigan, Minnesota, and Wisconsin. The Scandinavian nations and Japan lead in this area. While most foreign techniques do exist in the United States, many of these foreign producers have more experience in the use of modern production equipment for housing. Several foreign firms are large and efficient by U.S. standards. Some are parts of manufacturing concerns with access to elaborate research facilities and huge engineering staffs, and with experience in production engineering. In particular, Japanese and Swedish firms benefit from both highly automated factories and substantial government-sponsored research programs. Swedish, Finnish, British, Norwegian, and other foreign firms also have extensive experience in exporting their products to the Middle East and elsewhere. These firms may soon penetrate U.S. markets with housing components, and may license technology to domestic producers. Foreign firms have already penetrated domestic markets for kitchen equipment, especially appliances. Japanese air-conditioners and refrigerators, and components of these appliances, have moved rapidly into domestic markets, while U.S. exports of appliances have stagnated.

THE IMPACT OF FACTORY CONSTRUCTION

Factory-based home construction technologies could affect both housing production techniques and the nature of the homes produced. Specifically:

- Improvements could be made in both uniform quality standards and energy efficiency for homes. Written guarantees of quality can be provided more easily.
- Computer-assisted design methods could give prospective purchasers greater control over the products they buy, and a greater ability to understand the relationship between added amenities and added costs.
- Overall construction times could be reduced. Factory-made components place a finished house on a foundation in 1 to 10 days. Among other things, this savings in construction time might reduce seasonal variations in construction rates.
- The role of large firms could be increased. Smaller firms can serve as independent site-assemblers of manufactured products, or as franchised agents of major producers.
- The overall labor productivity of construction could be increased, thereby reducing net labor requirements.
- The skill levels of workers could be upgraded in order to operate complex production equipment. On the other hand, skill requirements might also be reduced if firms opt to design production around minimum wage workers.

Changes in the construction industry are extremely difficult to document because of the way that statistics are maintained. For example, some data on factory construction of housing components are combined with information on several other manufacturing industries, under the general area of "fabricated wood products." While anecdotal evidence supports statements about changes in such areas as skill levels in construction and the quality of different types of construction methods, reliable statistics are almost nonexistent.

BARRIERS TO THE ADOPTION OF NEW HOUSING TECHNOLOGY IN THE UNITED STATES

U.S. firms have been slow to adopt innovations in the production of housing for a variety of reasons:

- Wide swings in the demand for housing, resulting from the business cycle, changes in mortgage rates, and seasonal variations in home construction rates, make it difficult to justify large capital investments. It is far easier to maintain flexibility by laying off workers during slack periods.
- The regulation of housing in the United States developed in an environment where most builders were small firms operating in local markets. Housing regulation remains a State and local prerogative. Thousands of local code variations make it difficult for a single firm to oper-

ate in a market large enough to justify "economy of scale" production facilities. Interestingly, similar fragmentation in the appliance industry has led manufacturers to support strict Federal preemptive standards, which would negate the effects of conflicting State and local codes and would facilitate industry expansion.

- The industry is so fragmented and diverse that little research is conducted to improve the technology of either the structures produced or the manufacturing process. Government support of construction-related research is virtually nonexistent.
- The economic advantages of factory construction have not been clearly documented in the United States, although a number of anecdotes suggest that significant savings in labor and materials may be attained through improving construction techniques. But competition with conventional construction techniques has proven difficult in regions where conventional costs have remained low because employees will work for modest wages, with little job security. Also, the U.S. housing market has not put a premium on the quality that can be offered by factory construction.
- Housing markets in the United States have traditionally associated factory production with low-cost, low-quality, "prefab" units. In Sweden and Japan, however, factory construction has been marketed successfully because of its association with high reliability and high quality, as well as with advanced production techniques.
- Most homebuilders in the United States are too small to make the capital and engineering investments necessary to automate production.

INTERNATIONAL COMPETITION

Foreign penetration of the U.S. housing and manufactured building industries is most likely occur in the following areas:

- *Panelized Building Systems.*—Some foreign companies, especially the Scandinavians, will find profitable market niches, particularly in the Northeast and in areas of the country where high-quality material finishes, competitive prices, high insulation levels, and the "Nordic" mystique will prove salable. Substantial overall market penetration in the next few years is improbable. However, foreign technological developments—especially in Japan and Sweden —should be monitored closely, as should American market attitudes and trends.
- *Appliances.*—While the United States has enjoyed a favorable trade balance in residential appliances for many years, the terms of trade may be reversing. In fact, between 1979 and 1984, U.S. real dollar exports of household appliances declined by approximately 30 percent, while real dollar imports increased by over 67 percent. The Japanese are beginning to sell products ranging from room air-conditioners to refrigerators to high-efficiency light bulbs. Competition is likely to increase as living standards in Europe and Japan change in ways that make domestic markets for appliances more similar to those of the United States. At present many imported appliances have qualitative advantages over competing U.S. products, particularly in the area of energy efficiency.

  The impact of these developments is already being felt. Many appliances produced in the United States now contain high-value components, such as compressors, that are manufactured abroad. General Electric, the largest domestic producer of room air-conditioners, has announced that it will phase out operations at its main Louisville factory, and Carrier has drastically curtailed production in New York.
- *Wet Cores.*—While foreign wet core modules that combine plumbing, wiring, bathroom and kitchen fixtures, appliances, cabinets, electronic space conditioning, and communications controls have not yet made a significant appearance here, they would be cost-effective products for many foreign manufacturers. Custom cabinetry, bathroom fixtures, and electronic gadgetry are some of the housing components that have already proven attractive to U.S. homeowners. It may make economic sense for foreign manufacturers to combine these elements into "smart" modules with exotic designs and finishes.

- *Materials, Components, and Equipment.*—Foreign building-related products, including windows, kitchen cabinets, mechanical equipment, roof and floor tile finishes, and accessories, will gain an increasing share of the U.S. market. Although it is not within the scope of this report to provide research in this particular area, the potential impact on U.S. markets of foreign manufacturers may be significant. Several U.S. manufacturers assert that little organized or industrywide research has been conducted in this area.
- *Investors/Developers.*—A significant amount of foreign money has come into the United States for real estate development, most recently for the purchase of U.S. construction and design firms by foreign companies. In fact, heavy foreign investment has contributed significantly to the growth of the U.S. economy, despite the enormous balance of payments deficit. This trend will continue.

In some cases the purchase of a U.S. company has facilitated the entry of foreign companies into American markets by providing valuable insight into business trends. This purchase also allows the U.S. firm—and as a result, the foreign owner—to compete for U.S. Government projects nominally set aside for American companies.

Currently, few opportunities exist for U.S. firms to compete in overseas markets; the overall international construction industry has decreased in size over the past several years. Even within this restricted market, the relative share of U.S. firms has fallen. Factors affecting this trend include:

- increased competition from foreign contractors,
- lack of knowledge and experience in international trade,
- problems concerning building materials and building codes,
- trade restrictions,
- volatile political conditions in many foreign countries,
- corruption of foreign officials,
- distance from the United States to potential markets, and
- lack of U.S. Government support for trade initiatives.

Raw materials, such as wood and lumber, represent the only significant building-related export opportunity on the horizon for the United States. The only possibility for exporting U.S. manufactured buildings would be through assembling packages that combined buildings with project financing. Given appropriate investment in production and product design, U.S. firms could regain export markets for advanced appliances, controls, and other electronic equipment.

POLICY ALTERNATIVES

This document examines several possible remedies for the problems of the U.S. housing construction industry.

Improving the Fragmented System of Housing Regulation and Its Enforcement in the United States

At a recent conference hosted by the National Association of Home Builders, the major U.S. codemaking organizations[1] concluded that:

> . . . while there had been significant improvement over the years in administering and enforcing building codes, there were still disparities from one jurisdiction to the next in the way in which model building codes were adopted, interpreted, amended and enforced, which tends to defeat the primary purpose of creating uniform model building codes in the first place . . . the lack of reciprocity among regulatory jurisdictions and even the poor coordination among enforcement authorities within the same jurisdiction created unnecessary and costly delays in construction and thwarted the timely acceptance of new, cost-saving technologies.[2]

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[1] The National Conference of States on Building Codes and Standards, the Council of American Building Officials, the Building Officials and Code Administrators International and the International Conference of Building Officials, and the Southern Building Code Congress International.

[2] Council of American Building Officials, News Release, March 1986, Falls Church, VA.

Furthermore, some housing producers have complained about discrepancies between State transportation codes concerning truck loads, which discourage industry expansion.

Regulation can be made more uniform in several ways. First, the Federal Government could play a more active role. This might be done through a modification or expansion of the existing national HUD code system for regulating the production of "manufactured" (mobile) homes,[3] although this system should be examined carefully before it is applied to other categories of housing. Second, a new system of uniform national standards could be devised, which could be either mandatory or constructed so that States would voluntarily elect to enter the Federal framework. Third, a series of State compacts and reciprocal agreements could be established, and encouraged by the Federal Government. Fourth, private systems could be implemented.

The meeting of home builders and code officials cited above endorsed a plan that would be administered by the States. A single code would be adopted by each State, and a uniform program of enforcement would be developed. "The code would be mandatory for all factory produced housing and all site-built housing constructed in jurisdictions currently using building codes."[4] A key element would be reciprocity, in which each State would accept the inspections of housing components conducted by other States.

Other options for action by regional groups or by the Federal Government include: developing systems in which third-party inspectors, such as Underwriters Laboratories, could undertake a larger share of the burden of inspection; providing support or guidance in training local inspectors and regulatory officials; providing assistance in the creation of new standards; and developing testing equipment to monitor these standards.

Any action that reduces the fragmentation of U.S. housing markets is likely to benefit large American construction firms, and may make domestic markets more comprehensible, and thereby more attractive, to both foreign and domestic companies. However, a "least common denominator" code could result, which may reduce the quality of housing regulation, or may create incentives to "build down" to minimum standards.

Revising the Current Process of Inspection for "Manufactured" (Mobile) Homes

Serious questions have been raised about the adequacy of the HUD inspection system even in its present form. A recent HUD-sponsored survey of "manufactured" (mobile) homes covered by HUD regulations found:

> . . . an average of approximately 6.5 reported and/or observed problems per house which were identified in 78 or 96 percent of the houses inspected . . . Sixty-five (65) or approximately 80 percent of the houses had additional problems which were observed by the field inspectors and had not been, in most cases, reported in the earlier [telephone] survey . . . The number of problems reported in the survey raised questions regarding the integrity and quality of the houses which were produced during the 1977-1981 time period covered by this sample. The concern raised is validated by the number of affected houses and the number of problems *observed* by the field inspectors.[5]

The report concluded that "HUD should consider revising the Federal Standards to address long term requirements for material performance . . . [Inspectors] should increase the attention given to workmanship on the production line, and increase their observations of in-plant testing."[6] If a national strategy is developed to improve regulation and enforcement systems for factory-built housing, it may be necessary to integrate regulation of "manufuactured" (mobile) homes into the new system.

Labeling Building Quality

Labels that provide specialized information about the housing construction industry to potential buyers, bankers, and insurance firms can lead to technical improvements without mandating proscriptive regulation in areas not essential to health and safety. Labels might indicate that structures or components meet a fixed threshold of performance, much like the home energy rating systems now in place in a number of States and cities, or like the Japanese "Better Living" label that qualifies building components for group insurance. Energy efficiency labels could help purchasers make choices about houses in much the same way that miles-per-gallon stickers on automobiles or energy efficiency labels on refrigerators assist consumer decisions.

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[3] The Housing and Community Development Act of 1980 (Public Law 96-399) required that the term "mobile home" used in the statute establishing HUD's current mobile home inspection system be changed to "manufactured." This congressional intervention in semantics is admittedly confusing. See ch. 2 for a discussion of the nomenclature used to describe factory-built homes.

[4] CABO, op. cit., 1986.

[5] Resources Applications, Designs & Controls, Inc. (RADCO), "Final Report for Durability in Manufactured Homes," HUD Contract H-10992, Dec. 27, 1985, p. 77.

[6] Ibid., p. 4.

Increasing Government Support of Research in Building Technology

Despite the importance of research to the national economy, and its role as a major employer, neither the U.S. housing industry nor the U.S. Government have supported major research efforts to improve housing products or to upgrade the methods by which houses are built. While many component manufacturers have conducted significant studies, there is little support for an examination of how the house operates as an integrated unit to enhance human comfort. Misawa Homes of Japan spent 1.5 percent of its 1984 sales on research. Sweden, with a population of 9 million, spends more on housing research than the United States.

Several methods may accelerate technical progress in housing. Research alone will not automatically lead to a more productive, competitive industry, but it is an important ingredient for success. The National Conference of States on Building Codes and Standards (NCSBCS) notes that:

> Progress cannot be made in the use of new safe technologies in the building field without adequate funding of generic research, such as that done by the National Bureau of Standards.[7]

Reducing Excessive Changes in Housing Demand

Several techniques have been proposed for providing a "countercyclical" stimulus to the industry through counter-cyclical incentives and other methods. These include temporary interest reduction for housing loans and permanent interest reduction for loans to low-income families; tax credits for buyers of new or renovated homes, and for mortgage firms that encourage housing development; and buyer subsidies via tax-exempt mortgage revenue bonds.

While this issue will be addressed, a comprehensive examination of counter-cyclical alternatives is beyond the scope of this report.

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[7] Comment of the National Conference of States on Building Codes and Standards, Inc., May 25, 1986.

Chapter 2

The Development of the U.S. Housing Construction Industry

Chapter 2

The Development of the U.S. Housing Construction Industry

Industrialized building techniques have grown in importance throughout the postwar period, and factory-built housing has gained a significant market share in many industrialized countries. However, inconsistencies in available data make international comparisons difficult to formulate. In the United States, 10 to 35 percent of all housing is now supplied from components produced largely in factories—25 to 50 percent, if "manuactured" (mobile) homes are included. Although "manufactured" (mobile) homes are virtually unknown outside the United States, several other countries produce a significant fraction of all housing in factories. Approximately 90 percent of Swedish single-family housing and 15 percent of all Japanese housing is factory-built; in Japan, the factory share is growing rapidly. Foreign developments will be discussed in more detail in chapter 4.

It is difficult to document the movement from "conventional" to "factory" construction techniques, due to the enormous variety of construction techniques now in use. Virtually all home construction employs some kind of factory-built component, such as prehung windows, doors, or roof trusses. On the other hand, even "modular" homes, which emerge from factories with bathroom fixtures in place and wallpaper on the walls, require some onsite work. The confusion over definitions has been compounded by the fact that the term "manufactured housing" is defined by statute to mean units more commonly called "mobile homes."[1] In this text, the term "factory-built" will be applied to complete units constructed in a factory, to be erected as a package on a construction site. The term will not cover components such as trusses or wall panels. At the turn of the century, the term "industrialized housing" referred to use of framing lumber produced in a lumber mill, as opposed to the prevailing hand-crafted site assembly of logs. We now call that "stick-building," and refer to factory-prepared housing as "industrialized." The variety of factory construction techniques now being used in the United States are described in box A.

Confusion over terminology translates into a statistical disparity, which raises questions about levels of industrialization within the industry. This can be seen by examining the two principal sources of information about factory construction in the United States (displayed in table 1). First, while the two estimates of total unit sales and total "manufactured" (mobile) home sales are close, estimates of sales in panelized housing differ by 350 percent. In modular/sectional housing, estimates differ by a factor of 2. Undoubtedly, most of the differences derive from conflicting definitions. Some of the "production builders" reported in *Automation in Housing* and the "industrialized builders" reported in *The Red Book* construct panels and subunits in their own facilities. Others build temporary "factories" near large-tract construction areas. Some simply use site-built construction techniques in warehouses, and then transport partially completed wall sections to the building. The two surveys document these activities in different ways.

The statistics also differ in that the *Automation in Housing* report presents a stratified sample of builders based on telephone surveys, while *The Red Book* data is derived from a mailed questionnaire. Using the *Automation in Housing* definitions and methods, nearly half of all U.S. homes are now constructed with factory-based techniques. Both data sets show that the share of "manufactured housing" (mobile homes) seems to be countercyclical, in that sales increase when the overall housing market declines. There was a significant drop in "manufactured" (mobile) home sales between 1972 and 1976, and sales also fell during the housing recovery of 1984 to 1985. The drop in sales during the early 1970s was due in part to the passage of statutes regulating "manufactured" housing at a national level. Use of other factory construction techniques, however, increases steadily in the *Automation in Housing* statistics, while *The Red Book* data indicate a decline in panelized housing.

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[1] Public Law 96-399, Sec. 308.

Box A.—U.S. Factory Construction Techniques

- *Precut Systems.*—Precut systems involve the factory packaging of structural elements, material components, and finishes. The builder receives a "kit of parts" that fit together, and employ some components elements. The major U.S. precut systems manufacturers frequently provide interim financing of 2 to 3 years for their homes, citing the owner/builder's "sweat equity" as a partial downpayment. Permanent financing is arranged upon completion of the home.
- *Panelized Systems.*—In panelized systems, two-dimensional, factory-produced structural units are erected and joined together on the site. Composite panels for walls, roofs, and floors may be used, which often incorporate structure, insulation, and exterior finishes. Closed panel systems may include interior finishes, exterior sheathing, and exterior finishes, and incorporate building services and insulation during fabrication—preventing the onsite inspection allowed for by open panel systems. Elements like windows, doors, and exterior siding may be integrated at the factory. Panels may be built with a number of materials: wood framed, steel framed, foam or honeycomb cored, stressed-skin, precast concrete, or lightweight cellular concrete. A panelized system may use roof and floor panels, or wall panels with roof and floor trusses.
- *Manufactured Housing (Mobile Homes).*—These three-dimensional homes are assembled in the factory on a steel chassis, and must satisfy HUD building codes. Onsite, they rest on a temporary foundation and are connected to the site utilities. Manufactured homes may be either "single-wide," where the house is a single unit, or "multi-wide," where two or more units comprise the final house. Recently, "double-wide" units, or two units side-by-side, have been erected on permanent foundations.
- *Modular Systems.*—Modular systems resemble mobile homes: factory-assembled "boxes" compose the final building. However, they differ in that modular units are transported by external carriers, and modular buildings may take on any size or shape. Modulars are usually wood framed. Concrete, which has been employed for large-scale highrise housing projects, has not proven to be cost-effective in the United States. Modulars must comply with conventional building codes, but are not subject to the Federal standards that govern mobile homes.
- *Wet Core Modules.*—A prefabricated element that can complement several building systems, the wet core module assumes a number of forms. It may contain bathroom, kitchen, and laundry facilities, with plumbing, stack fixtures, and interior finishes built in. Or, it may simply incorporate a plumbing wall with fixtures, but not necessarily the actual shells of rooms.
- *Wood Components.*—These two-dimensional structural parts of buildings—such as floor trusses, roof trusses, wall panels, beams, headers, and door and window assemblies—are used onsite by large-scale builders. Typically, up to 60 percent of a factory-built home may consist of pre-assembled wood components.

Table 1.—Factory Construction as a Percent of All Residential Construction in the United States

	1978	1979	1980	1981	1982	1983	1984	1985
Automation in Housing Survey:								
1 Production builders	63	74	75	75	55	48	51	52
2 Panelized	23	26	27	29	26	24	27	32
3 Modular	4	5	4	5	4	4	4	4
4 "Manufactured" (mobile)	14	16	17	21	23	17	17	18
5 Factory built (rows 2+3+4)	41	47	48	55	53	45	49	54

NOTES: Based on a stratified sample survey of subscribers to *Automation in Housing & Manufactured Home Dealer* and firms identified during earlier surveys. Subscribers produce about 90 percent of all housing units started in the United States each year. The sample does not include small custom builders some producers of high-rise structures. Production Builders are defined at large construction firms that sell products directly to customers. The Panel and Modular builders sell to builders/dealers. Some production builders use factory techniques for a part of their sales. Percent calculations use total private housing starts (U.S. Bureau of the Census, Construction Reports, C-20 Series) plus total "mobile" home production as the denomenator.

SOURCE: *Automation in Housing & Manufactured Home Dealer*, January 1986, p. 14 & 16.

Table 1.—Factory Construction as a Percent of All Residential Construction in the United States—Continued

	1978	1979	1980	1981	1982	1983	1984	1985
Red Book Survey:								
One to four units:								
1 Precut	1	1	1	2	1	1	1	1
2 Panelized	6	6	7	5	4	3	4	4
3 Modular/sectional	2	2	2	3	3	2	3	3
4 Mobile homes	12	14	14	18	18	15	15	14
5 Industrialized home builders	10	10	10	10	13	13	14	13
6 Others	48	45	43	42	36	38	36	37
Five or more units:								
7 Factory made	1	1	1	0	1	1	1	1
8 Other	20	20	22	21	24	26	27	27
Factory (1+2+3+4+7)	22	24	25	28	27	22	23	23
Industrialized	10	10	10	10	13	13	14	13
Others (6+9)	68	66	65	63	61	65	63	63
Total	2,296	2,026	1,526	1,327	1,292	1,992	2,000	1,900

NOTES: Precut homes are defined as "a sales package for which the many parts are pre-cut but not preassembled. Although roof trusses may be included preassembled wall panels are not." Modular/sectional homes are "three-dimensional housing unit(s) produced in a plant and designed for erection on a permanent foundation with a minimum of on-site labor." Industrialized builders are "real estate developers and builders . . . using industrialized building techniques whenever they are cost effective."

SOURCE: "The Red Book of Housing Manufacturers," 1985.

THE VARIOUS KINDS OF FACTORY-PRODUCED HOMES

"Manufactured" (Mobile) Homes

The structural box beam serves as the basic design principle of a "manufactured" (mobile) home. This integrated structural unit consists of four major subassemblies, into which are incorporated several mechanical service systems: the chassis, and the floor, wall, and roof systems. Nonstructural assemblies include such units as cabinets and windows. Figure 1 provides an exploded view of a "manufactured" (mobile) home, resting on a chassis.

Single-wide "manufactured" (mobile) homes are completed in the factory. However, multisection homes generally consist of three walls, a roof, and a floor, all of which are joined at the site. The arrangement of sections at the building site allows for greater flexibility in floor plan designs. Both single and multisection homes conform to maximum highway width loads—typically 14 feet. The Manufactured Housing Institute's 1985 publication *Quick Facts* reported that 29 percent of all "manufactured" (mobile) homes shipped in 1984 were multisection homes. Due to their large size, these homes may overlap markets for other types of industrialized housing.

According to a recent study of the "manufactured" (mobile) home industry, construction processes for these units can be divided into three basic activities: assembly, or the actual construction of product units; material storage of supplies, components, or product units until they are used in the production process or are shipped from the plant; and material handling, or the transportation of materials for storage, shipping, or use in assembly activities.[2] Each phase must be carefully coordinated and integrated within the production system in order to complete the unit successfully.

The typical "manufactured" (mobile) home plant is housed within a single-story "manufactured" metal building with an average floor area of 64,000 square feet. Normally, plant layouts and assembly lines fall into three different types: straight, L-shaped, and U-shaped. Subassembly and storage areas are located in designated areas around the periphery of the assembly lines. Units move along the assembly lines either end-to-end or side-by-side. The side-by-side placement method has become prevalent, as it permits more efficient factory space utilization. Furthermore, the side-by-side arrangement is desirable for producing multiunit "manufactured" (mobile) homes, since two or more units can be mated onsite to be

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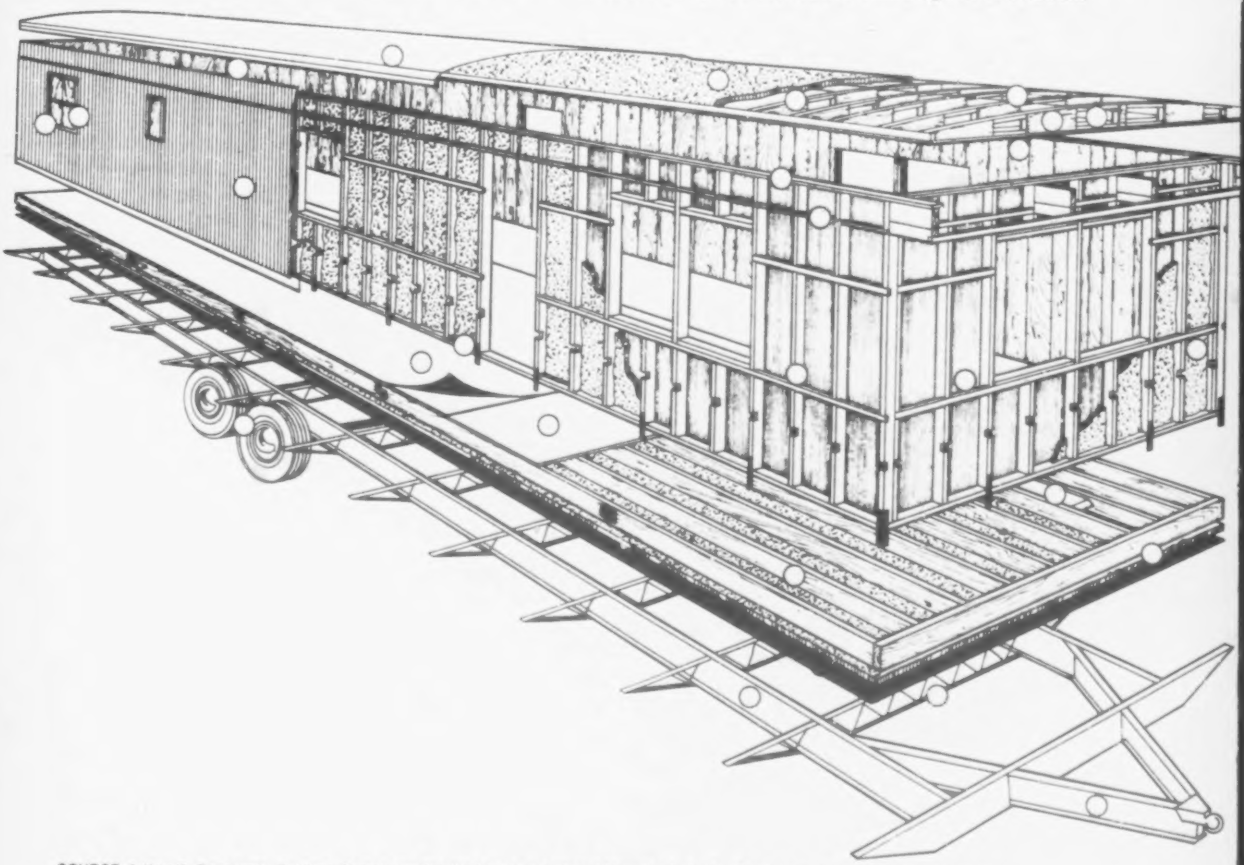
[2] Arthur D. Bernhardt, *Building Tomorrow: The Mobile/Manufactured Housing Industry* (Cambridge, MA: MIT Press, 1980).

Figure 1.—Exploded View of a "Manufactured" (Mobile) Home Resting on a Chassis



SOURCE: Arthur D. Bernhardt, *Building Tomorrow: The Mobile/Manufactured Housing Industry* (Cambridge, MA: The MIT Press, 1980).

assembled side-by-side, allowing for improved alignments and closer tolerances.

The Manufactured Housing Institute estimated that in 1983, approximately 185 firms shipped "manufactured" (mobile) homes from 410 factory sites. The average number of units shipped per plant was 582. With material costs accounting for 65 to 70 percent of the total cost per unit, more efficient material purchases can substantially improve the cost performance of a given production facility. Firms with many plants can realize even greater economies of scale.

Most "manufactured" (mobile) home plants follow a sequence of basic assembly operations. Production of the "manufactured" (mobile) home unit proceeds from the bottom up and from the inside out, beginning with the chassis frame and moving to the floor, wall, and roof assemblies. As the unit moves along the main assembly line, subassemblies are added at the appropriate points. Some manufacturers purchase subassemblies and components from other companies. The extent to which subassemblies and components are fabricated in the plant depends on such factors as the availability of labor and materials, local shipping costs, and the proximity of suppliers.

Normally, 1 to 3 days are required to assemble a "manufactured" (mobile) home, depending on market demand, plant facilities, and unit specifications, with an average of 250 man-hours per unit. Most workers operate in crews, and are responsible for a specific assembly or fabrication operation on a rotating basis.

Once assembly operations are completed in the factory, the units are transported to the homesite, to a builder/dealer's display lot, or to a storage facility. The units' chassis are attached to trucks, and can be transported within a radius of approximately 500 miles. From the manufacturer's point of view, however, the "feasible" shipping radius depends on market demand, transportation costs, and the location of competitors. The truck is the most economical means for transporting "manufactured" (mobile) homes, although several manufacturers have used rail and ship transport. The dealer installs approximately two-thirds of the units sold.

Upon reaching the site, the "manufactured" (mobile) home is positioned, unlatched from the transport vehicle, and stripped of its wheels. For multicomponent "manufactured" (mobile) homes, sections must be positioned and joined. Finally, the unit is connected to utility and sewer systems. Less than 15 percent of the units installed between 1970 and 1976 had been moved from their original location by 1983.[3] Approximately 7 percent of the owner-occupied units and 4.5 percent of the renter-occupied units are installed on permanent foundations, and another 12 to 15 percent are installed on a concrete pad. The remainder rest directly on blocks, without a concrete pad.[4] Multisection units have declined in importance, after peaking at about 25 percent of all units sold in 1978. By 1983, they represented less than 15 percent of the units shipped.[5]

"Manufactured" (mobile) homes serve a relatively well-defined market niche. With an initial price per square foot of about 60 percent of a site-built house, they are the principal choice of families looking for housing with an initial cost of under $50,000.[6] Table 2, based on data published by the Manufactured Housing Institute, indicates that in 1983, "manufactured" (mobile) homes captured 82 percent of the market for single-family homes valued at less than $50,000—an absolute increase of 44 percent from the market share of 38 percent in 1977. This significant increase did not result from a surge in "manufactured" (mobile) home production; rather, the total number of site-built homes selling for under $50,000 declined from 433,000 units in 1977 to only 65,000 units in 1983.

Figure 2 compares the income characteristics of families living in "manufactured" (mobile) housing with that of all families living in purchased or rented housing. In 1983, nearly three-quarters of all "manufactured" (mobile) homes were inhabited by families with incomes of less than $20,000, while three-quarters of all housing was owned by families with incomes of less than $35,000. In fact, a recent study conducted for the U.S. Department of Energy indicates that in 1980, the median income of "manufactured" (mobile) home residents was $12,000, while that of other single-family detached homeowners was $19,800.[7] It is interesting to note, however, that "manufactured" (mobile) housing does have a significant market share in the higher income categories; in 1983, for example, 7,000 families with incomes over $100,000 per year reported that their principle residence was a "manufactured" (mobile) home.[8]

The real cost of a housing unit, of course, requires deeper analysis than the initial unit cost. Such research could consider the quality of the housing produced, the expected life of the unit, and the cost of operating and maintaining the unit. Some of these trade-offs will be discussed in chapter 3.

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[3] Westat, Inc., "Analysis of the Annual Housing Data (AHS) Pertaining to the Durability of Manufactured Housing" (Rockville, MD: 1986), p. 2.9.

[4] Ibid., p. 2.11.

[5] Ibid., p. 2-10.

[6] Manufactured Housing Institute; see table 8 in ch. 3.

[7] Pacific Northwest Laboratory, "Impact of Alternative Residential Energy Standards," November 1985, p. 3.3.

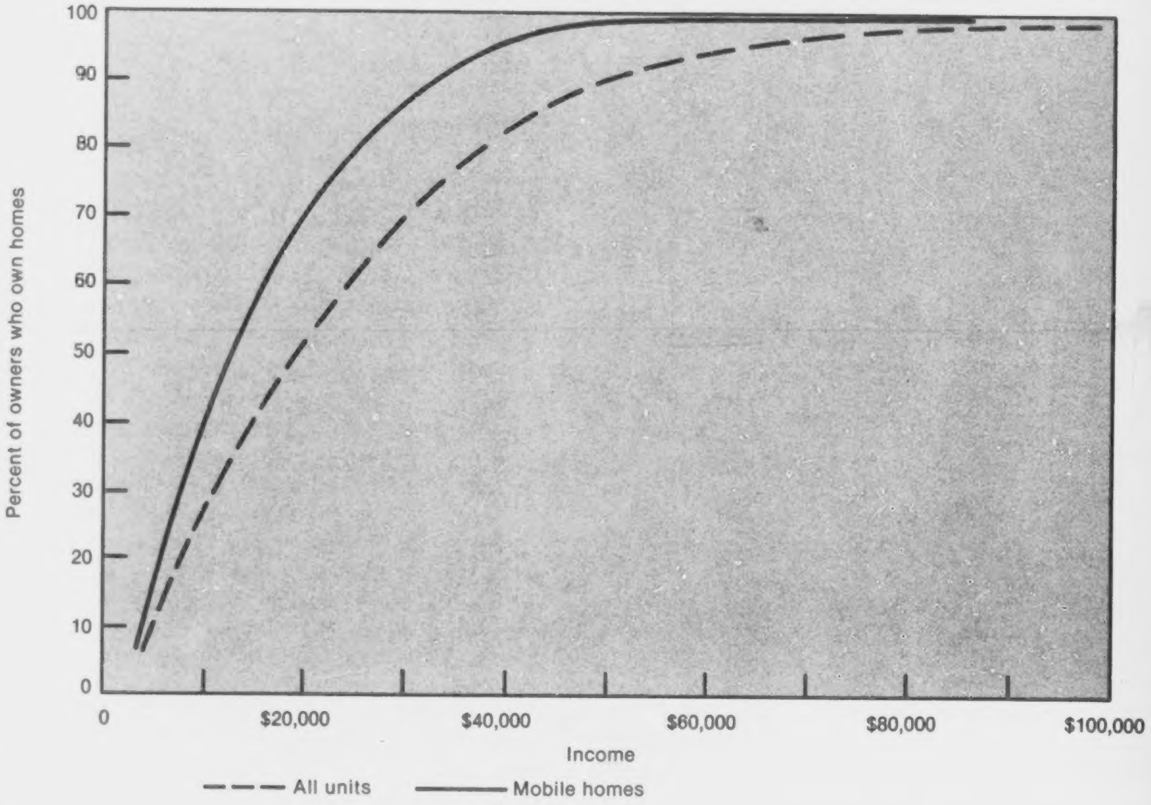
[8] U.S. Department of Commerce, Bureau of the Census, "Annual Housing Survey: 1983," p. A-11.

Table 2.—Comparison of Mobile Home Shipments and Sales of Single-Family Site-Built Homes for Under $50,000, 1977-83 (in thousands)

	1977		1978		1979		1980		1981		1982		1983	
	Number	Percent of total	Number	Percent of total	Number	Percent of total	Number	Percent of total	Number	Percent of total	Number	Percent of total	Number	Percent of total
Site-built homes sold	433	62	316	53	184	40	137	38	88	27	67	22	65	18
Mobile homes shipped	267	38	276	47	277	60	222	62	241	73	239	78	295	82
Total new	700		592		461		359		329		306		360	

SOURCE: Manufactured Housing Institute

Figure 2.—Home Ownership by Income Cohort for 1983



SOURCE: Manufacturing Housing Institute.

Most manufactured housing plants are located in small rural communities, particularly in the sunbelt region. The rural areas provide both the principal consumer makets and favorable labor markets, due to the presence of low-skilled and non-unionized workers. Manufactured housing is concentrated in the South, which held 46.2 percent of the market in 1983; only 8.1 percent of all units are located in the Northeast.[9] Approximately half of these units are sited individually or in clusters of 5 or fewer, while about one-quarter are situated in clusters with 100 or more units.[10]

Modular Homes

Modular systems resemble "manufactured" (mobile) homes. The final building is composed of factory-assembled, three-dimensional "boxes" (see figure 3). However, modular units are transported by external carriers, and modular buildings—including small hotels/motels and commercial buildings—may be constructed from any number of boxes. These boxes can be stacked seven stories high to form multistory residential and commercial structures. Unlike "manufactured" (mobile) housing, which is regulated by the national HUD code, modular homes must satisfy State and local building codes.

Modulars are among the strongest of all light-frame residential structures. They are built with completed

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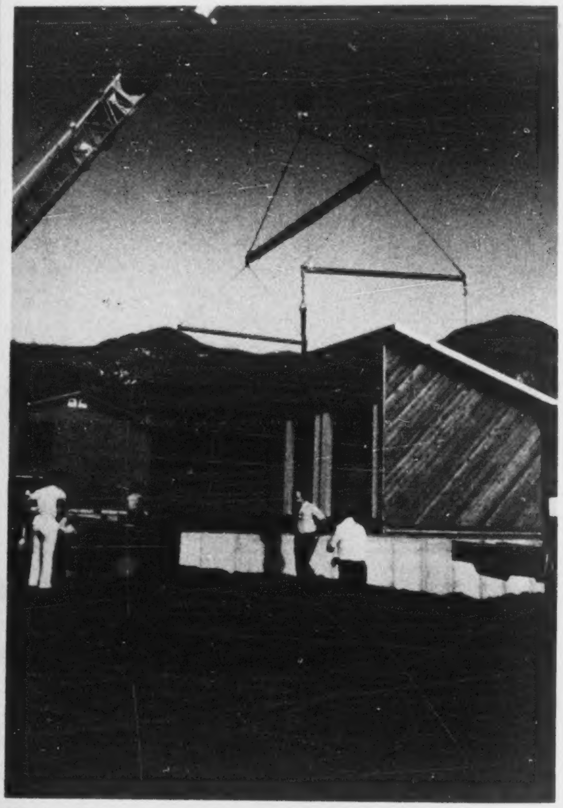
[9] Westat, op. cit., p. 2.2

[10] Ibid., p. 2.6.

Figure 3.—Double-Wide Modular Home



Double-wide modular (or sectional) home. It arrives at the building site in two sections—split down the roof line—and is joined together and set on the top of the foundation.

SOURCE: Don O. Carlson.

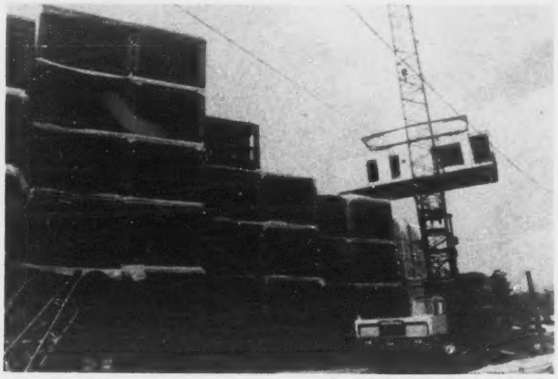


Photo credit: Don O. Carlson

A five-story building constructed with stacked modulars.

sheathing for roofs, sidewalls, and marriage walls with glue-nailed plywood, and employ heavier-than-normal construction techniques in wall and floor section framings. Modular housing units come in a variety of styles and sizes.

According to *Automation in Housing* magazine, 200 plants manufactured modular homes in 1983, with the typical plant building 350 homes per year and employing 109 persons. Factory layouts, machinery, equipment, and assembly processes for producing modular units resemble those described for "manufactured" (mobile) homes. However, since modular units are not built on a wheeled chassis, they either move through the production line on roller systems or are placed on a temporary trailer assembly. Electronic airlifts place the finished sections onto shipping vehicles for transportation to the site.

Generally, trucks transport modular sections to the site. Site cranes then remove and position the sections on a permanent foundation. Helicopters can be used for transporting the units when special problems arise, such as bridges or tunnels.

Again, because modular units lack a structural frame chassis, they rest on permanent foundations. This necessitates significant site preparation work before the unit's arrival. The recently developed "all weather wood foundation" (AWWF) systems, which cut costs and onsite assembly time when compared with traditional concrete foundations, are now used throughout the industry. AWWFs are assemblies of frame walls built of low-grade, preservative-treated lumber and plywood to create basement and crawlspace foundations. In comparison with conventional cement foundations, the AWWF can be erected quickly in extreme climates, which normally make concrete work difficult. As a result, they can extend construction seasons in many areas. This provides greater continuity in employment, and lowers costs in areas sensitive to "land factors." Furthermore, the development of prefabricated foundation systems has eliminated the setup or drying time encountered with cement foundations, and skilled labor is not required for their assembly.

When the modular unit is secured on the foundation, sectional joint work commences using specialized connector plates as well as pneumatically driven fasteners. Joints are then sealed and the utility and sewer systems are connected to the main lines. The sections are sealed together with moisture-proof barriers, to ensure consistent moisture protection and energy efficiency. The Swedes make sure that this is done, and take great care to train installers.

The market for modular homes has growth potential in the area of infill housing, or that which is constructed between two existing structures. Stacked modular units can satisfy the need for high-density, smaller sized housing units in urban areas around the country.

Panelized Homes

Like modular homes, panelized homes come in an array of types, sizes, and interior/exterior finishes. Panels may be produced in lengths of 2 by 8 feet or 4 by 8 feet that are erected by one or two workmen, in lengths of 10 to 16 feet that can be erected by four workmen, or in sizes of over 16 feet which require a crane for erection.

Automation in Housing reports that approximately 600 companies produced panelized homes in 1983. The panels themselves fall into two classifications, open and closed. Open panels refer to factory-assembled wall, floor, or roof panels that are open on one or both sides so that construction and/or enclosed mechanical, electrical, or plumbing equipment can be inspected onsite. An exterior open panel wall may have sheathing, doors, windows, and siding on the outside and insulation between the studs, but will lack finished materials such as drywall on the inside surface. In contrast, closed panels are enclosed on both sides, severely limiting access to onsite inspection. Panel factories typically contain linear production lines with automated sawing machinery and pneumatic panel nailers and staplers.

Panelized components can be loaded for shipping by truck or rail. Improved shipping techniques allow panelized home manufacturers to service greater market ranges than "manufactured" (mobile) or modular home producers.

A major disadvantage of panelized structures is the onsite labor required to assemble such systems. Poorly trained installers can increase costs and reduce quality. Although high-quality and tolerance standards exist in the factory, the ultimate quality of the structure depends on the skills and experience of the contractor who assembles the system at the building site. Currently, few U.S. panelized manufacturers provide their own building crews for onsite assembly operations. The Swedish discovered that quality assurance required them to have panels erected by either their own employees or teams trained by the manufacturing firm (see ch. 3). Swedish firms guarantee the installed product.

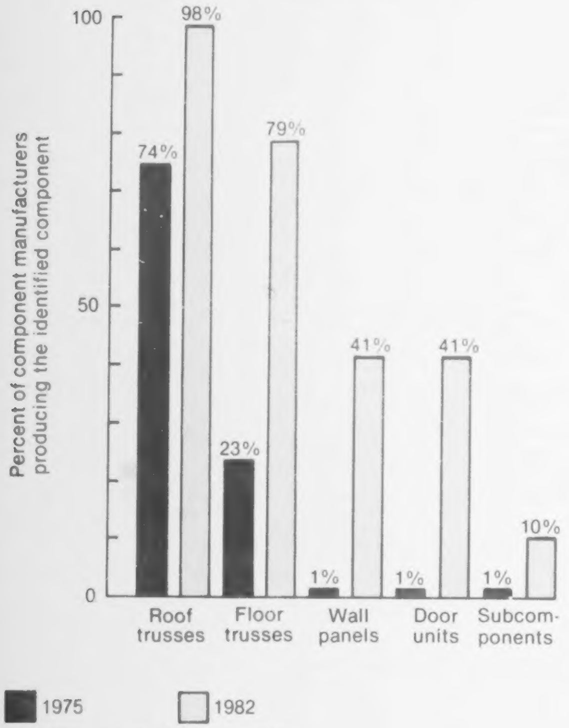
Precut Systems

Precut systems, which include log homes, dome houses, and precut frame houses, are produced in the factory and shipped to the site as packages. The builder receives a "kit of parts," such as framing envelope components, windows and doors. All elements are designed to fit together and are cut to size. These systems use certain individual components, such as roof trusses. Generally, the leading U.S. precut systems manufacturers provide 2- to 3-year interim financing for their homes, using the owner/builder's "sweat equity" as a partial downpayment. Permanent financing is arranged upon completion of the house. There are approximately 250 log-home manufacturers and 60 dome-house producers in the United States today.

Component Systems

Although not strictly a building system, manufactured building components play an important role in conventional construction. The invention of the metal truss connector plate was of enormous benefit to component manufacturers. This stamped metal plate that can join truss members, can splice chords of trusses, can join members of rough openings for doors and windows, or can fabricate other components. In 1982, virtually all of the Nation's 2,000 component manufacturers produced roof trusses, and nearly 80 percent produced floor trusses. Figure 4 provides a diversification trend chart depicting the component manufacturers' tendency to expand prod-

Figure 4.—Diversification Trends of Component Manufacturers



SOURCE: *Automation in Housing*, 1983.

uct lines by including wall panels, door units, and other subcomponents. Recently, however, HUD announced that a significant number of roof trusses used in prefabricated industrialized housing had failed.[11] Careful regulation in this area could provide consumers with greater protection.

Over 90 percent of America's homes and apartments are built with roof trusses that have been connected by metal plates. Advances in computer technology have led to the widespread application of prefabricated truss assemblies in homebuilding operations. Roof trusses come in many configurations; computer software programs provide instantaneous design information concerning loading and stress factors, and indicate material and cost requirements associated with particular designs. Futhermore, roof truss assembly has become increasingly automated. To move truss presses, the truss members and plate connectors sit on a conveyer, which moves the assembly under a roller that squeezes several joints at a time.

Roof trusses typically span a 32-foot wide house and are spaced up to 24 inches from the center. They can be set in place in minutes and, with the application of conventional 4 by 8 foot sheets of plywood as sheathing over the top chord, can close a house to the weather in less than a day.

After roof trusses, the 1970 invention of the floor truss represents the second major breakthrough for the American home building industry. These systems are made with 2-by-4 top and bottom chords placed flatwise with 2-by-4 webs, which are fastened with metal connector plates. Another advance came in 1976, with the invention of the metal web connected floor truss. This replaces all or portions of the 2-by-4 webs with a triangular metal web. Integral connector teeth protrude from each of the three points of the web, which is then attached to the outside edges of the chords. The floor truss assembly machinery operates on the same principle as roof truss assembly machines; the wood framing members are positioned on a truss machine, which presses the plate connectors onto the joints.

Component manufacturers also make prehung doors and windows; prefabricated stairs; and subcomponents like corners, tees, and headers (see figure 5). All segments of the housing industry use these wood components, largely because the light frame wood system that predominates in this country is an "open system." These components can be used by virtually all builders.

Some component manufacturers specialize in the production of wet core modules. Although not an actual building system, a wet core module is a prefabricated element that can fit with a number of building types. In its most developed form, it consists of a module containing the bathroom, kitchen, and laundry facilities for a home, with plumbing, stack, fixtures, and interior finishes built in. In a less developed form, it may incorporate fixtures into a plumbing wall, but not necessarily into the actual shells of the rooms. By industrializing a highly labor-intensive segment of the traditional housing construction process, these components can produce significant cost savings for the builder.

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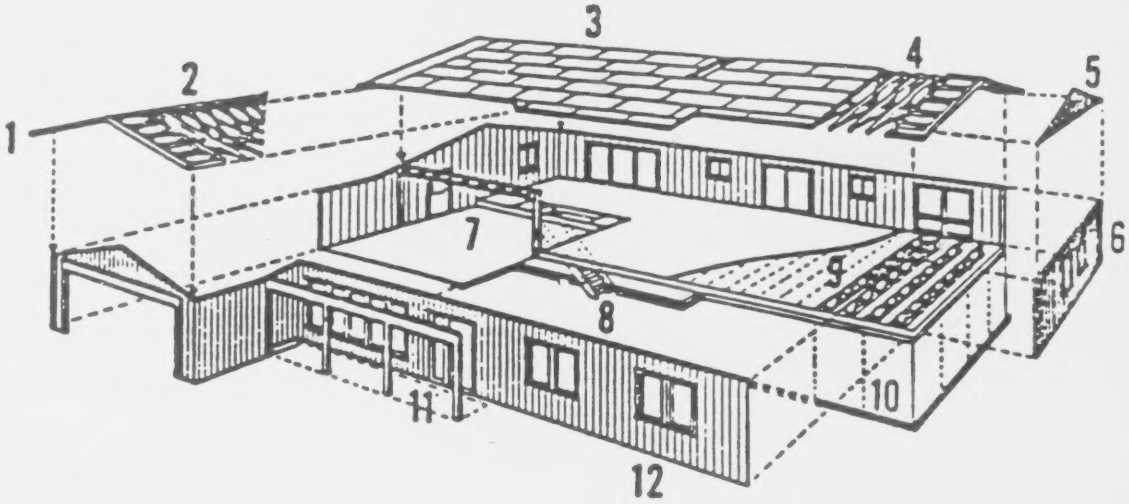
[11] Comment of the National Conference of States on Building Codes and Standards, Inc., May 25, 1986.

Figure 5.—Component Framing Assemblies



Newer component framing house part assemblies:

1. Ladder rake overhang assembly
2. Valley roof trusses
3. Roof sheathing
4. Engineered roof trusses
5. Gable end
6. Wall panels
7. Garage door header truss
8. Pre-assembled stairs
9. Engineered floor trusses
10. Wood foundation panels
11. Prehung doors
12. Prehung windows

SOURCE: *Automation in Housing*, 1983.

INDUSTRY SEGMENTS

The housing industry includes producers, distributors, sellers of the end product, and other segments. The housing units that these segments produce—"manufactured" (mobile), modular, panelized, precut, and component systems—were presented in the preceding section.

Categories of housing producers are not entirely distinct from one another. Some firms manufacture more than one type of housing; for instance, several "manufactured" (mobile) housing producers make modulars as well. These producers try to maintain stability in an unstable market by retaining flexibility in their plants. When demand for one type of product, like single-family homes, declines, they emphasize another, such as multifamily units. This approach may become increasingly popular in the U.S. residential construction industry.

Production Builders

This segment consists of large and small volume site builders, who use factory-made housing components to construct large numbers of single-family houses or low-rise apartment buildings in subdivisions, or "tracts," near major metropolitan centers. Typically, their structures consist of prefabricated factory or onsite components. Often called "volume producers of housing," production builders do not use networks of builder/dealers, but sell homes directly to the consumer.

Increases in site-labor and construction loan costs have made production builders the principal consumers of prefabricated housing components. While some large production builders now operate their own component manufacturing systems, most still secure components from independent companies.

Builder/Dealers

"Manufactured" (mobile), modular, and panelized home manufacturers usually sell their products through networks of builder/dealers. These builder/dealers often operate from display lots, located within 700 miles of "manufactured" (mobile) and modular home manufacturing plants due to transportation constraints. Builder/dealers may sell for one or several manufacturers, and do most of their business in well-defined market areas. In addition to acting as salespersons, builder/dealers prepare the land, complete foundation and utility work, and supervise finishing work on the home after delivery.

Figure 6 illustrates the functional interrelationships among manufacturers, wholesalers, fabricators, builders, dealers, contractors, and consumers associated with the manufactured housing industry.

Small Builders

Small operators constitute the vast majority of American homebuilders—far too small, in terms of units produced per year, capital resources, and scope of operations, to handle the large capital expense of introducing new technologies.

Concerning output, the 1977 Census of Governments reported that 227,830 general building contractors, nearly 80 percent of all general contractor establishments, had receipts of less than $250,000, which translates into 5 to 10 units per year. Similarly, the National Association of Home Builders (NAHB) states that the vast majority of its member firms produce fewer than 25 houses per year. And the 1977 Census of Construction concluded that one-fourth of all homebuilders operate in a single market area, and that less than 5 percent of all builders of single-family units worked outside their home States.

These small firms do exhibit a strong entrepreneurial nature. When market conditions change, they move out of homebuilding and into more promising construction endeavors. In the so-called "bad years" of 1967, 1974, and 1975, nearly 20 percent of member firms surveyed by the NAHB in 1977 switched to other businesses. Members switched at half this rate during periods of success.

Small producers often capitalize on short-term investments. They should be able to adjust finances quickly, so as to reinvest in new efforts according to market trends. Such producers can operate more flexibly and more economically with unskilled or semiskilled workers than with costly new machinery. Given these considerations, the large-scale, long-term capital requirements associated with technological innovation conflict with the needs and capabilities of most American builders.

U.S. Home: A Case History

U.S. Home Corp., until recently the Nation's largest homebuilding firm, serves as an example of a large company that has changed its market approach in order to satisfy housing demand—sometimes against its will. Started by New Jersey builder Robert Winnerman, this company produced an estimated 2,400 houses in 1968, generating revenues of $58.3 million. U.S. Home became a national force the following year, when Arthur and Charles Rutenberg incorporated their separate Florida firms with that of Winnerman.[12] During the next 3 years, Winnerman acquired 14 other firms. By 1973, U.S. Home operated in 11 national markets; production had increased to 10,700 units, and revenues to $351 million. Production peaked in 1980, at 15,821 units.

In 1982, U.S. Home delivered 12,599 units, down from its previous high, although it still enjoyed operating revenues of $832 million. Over half of this production was situated in Texas, where the success of the oil industry had created an unusually high demand for housing. By 1983, U.S. Home had opened 74 divisions and 13 manufacturing plants in 25 States. They were building in 175 single-family detached communities, 109 condominium projects, and 9 retirement communities.

U.S. Home's 1983 annual report indicates several actions taken by the company to protect and expand its market. It was the first major homebuilder to develop and issue "collateralized mortgage obligations" (CMO) funds. CMOs raise new mortgage credit by selling securities that are "collateralized" by loan payments made on previously sold homes; these funds are then earmarked to make loans to purchasers of

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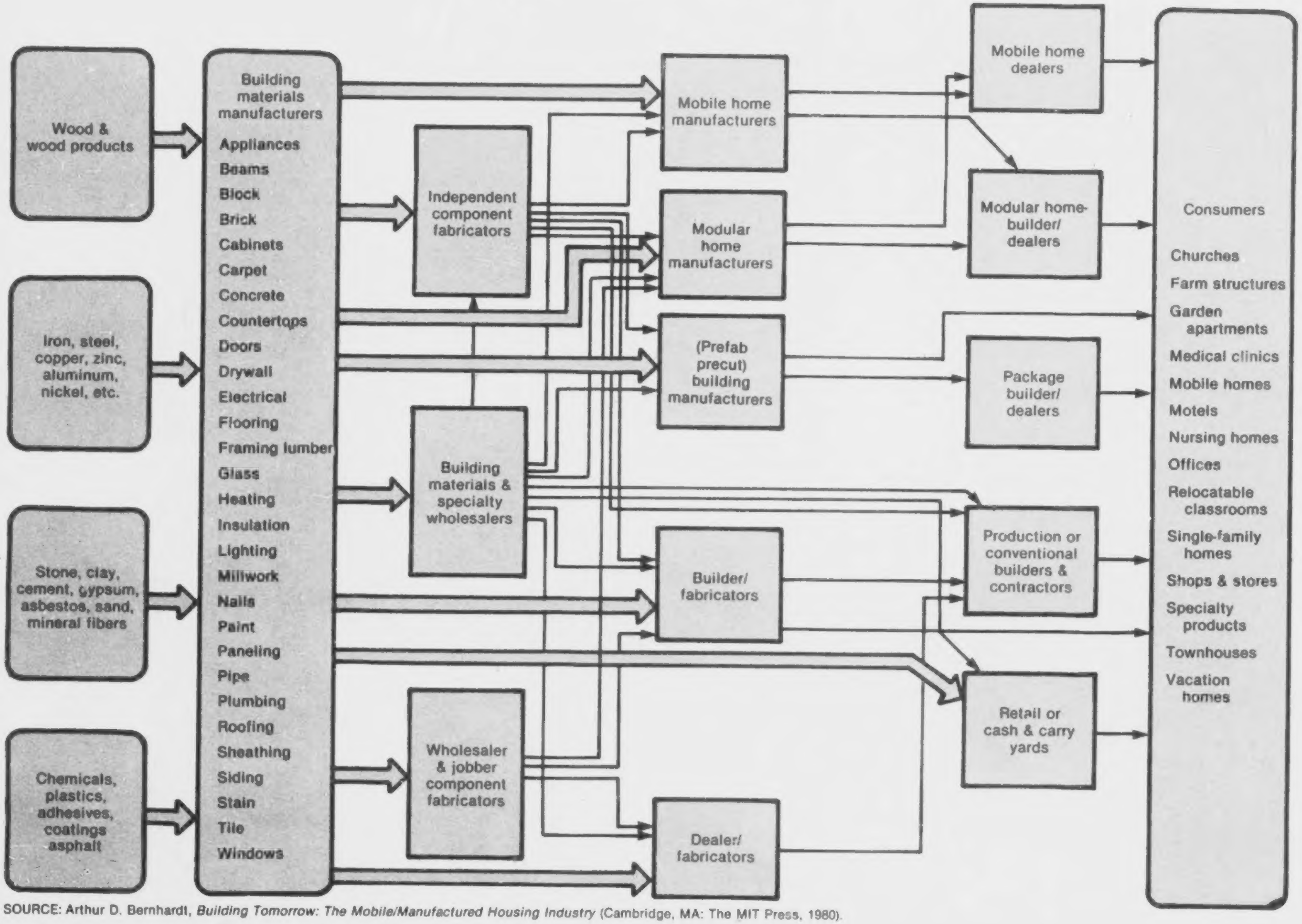
[12] Ned Eichler, *The Merchant Builder* (Cambridge, MA: The MIT Press, 1982), p. 187.

Figure 6.—A Model of the Industry



SOURCE: Arthur D. Bernhardt, *Building Tomorrow: The Mobile/Manufactured Housing Industry* (Cambridge, MA: The MIT Press, 1980).

new homes. In 1983, U.S. Home learned of projections that the bulk of future demand for new housing would be in rural and small metropolitan areas. In order to adapt to the changing nature of the market, the company acquired Brigadier Industries Corp., one of the Nation's largest producers of "manufactured" (mobile) housing. This move was intended to improve U.S. Home's ability to operate efficiently in small markets, and to facilitate its pledge to offer housing at competitive prices.

However, U.S. Home did not anticipate the downslide of the oil industry and the resulting decrease in housing demand. The firm had entered the "manufactured" (mobile) home market to capitalize on the immediate need for low-cost housing; in much the same way, it opened the largest industrialized housing plant in Salt Lake City during the overthrust drilling boom of the late 1970s and early 1980s. When the oil market collapsed, U.S. Home was faced with a manufacturing capacity that outstripped demand by a large margin. The firm has confronted this problem by abandoning production of both "manufactured" (mobile) homes and modular units, and it is currently negotiating to sell off its Brigadier subsidiary.

Like many other producers of factory-built housing, U.S. Home has met with both success and failure in its attempts to operate within a volatile market. Because it has continued to profit from certain segments even during periods of financial duress, it has been able to overcome setbacks in a particular housing category. Its case history demonstrates the risks involved in adapting to industry developments as they occur, and the manner in which a company may readjust to the effects of such changes.

TRENDS IN INDUSTRIALIZED HOUSING

The Early Years

In the United States, prefabricated building technologies received widespread attention as early as the 1930s. Having witnessed the technological success of the automobile industry, the American public believed that mass production of houses would alleviate the Nation's chronic shortage of affordable housing. In 1932, *Fortune* referred to General Homes, Inc., which had just unveiled its prefabricated steel house, as "the General Motors of the new industry of shelter," commenting on the construction of General Homes' prefabricated steel house.[13] By 1933, prefabricated housing companies were attempting to capture a share of the potentially vast market for mass-produced homes. Even industrial giants such as Armco Steel, American Rolling Mills, Wheeling Steel, Great Lakes Steel, and Goodyear—all of whom envisioned that mass-produced housing would generate profitable markets for their own building materials and components—began investing in home manufacturing operations.

But early dreams of capitalizing on the prefabricated home faded quickly. One housing analyst cites three reasons: "the price of the prefabricated house was not competitive, public interest stopped short of purchase, and promised capital backing proved elusive."[14] Inconsistent local codes and management errors also contributed to the problem.

Few U.S. firms mass produced prefabricated housing prior to World War II. As one study suggests:

> Up until the Second World War, prefabricated housing accounted for only one half of one percent of total housing construction. The War radically changed that figure. The need for large scale production at minimum cost and maximum speed gave established prefabricators and would be prefabricators a golden opportunity. The Federal Public Housing Authority alone built some 116,000 prefab houses and about 80,000 more were built by other government agencies and by private operators.[15]

This rapid expansion of prefabricated housing production during the war also stimulated new business ventures within the field.

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[13] "Housing: A Striking Answer," *Fortune*, August 1932, p. 60.

[14] W.D. Keating, *Emerging Patterns of Corporate Entry Into Housing* (Berkeley, CA: IURD Press, 1972).

[15] Ibid.

Following World War II, the United States experienced a housing crisis of unprecedented proportions. In response to a critical shortage of homes, President Truman appointed Wilson Wyatt as Housing Expeditor. Wyatt had full privileges to use the War Powers Act and the War Mobilization and Reconversion Act, and had direct control of the Federal Housing Authority and the Federal Home Loan Bank Board. He presented the Veteran's Emergency Housing Program on February 7, 1946. This program:

> . . . set a production target of 2.7 million units for the years 1946 and 1947. To reach this unprecedented goal, Wyatt intended to rely heavily upon prefabricated housing, 250,000 units in 1946 and 600,000 in 1947. Achievement of this goal would have increased the value of prefab production from $100 million to $2.5 billion.[16]

As it turned out, only 37,200 prefabricated units were constructed in 1946, and 37,400 in 1947. The Wyatt program died out by 1948, and cost the Federal Government approximately $200 million. Many housing producers, including those with technically sound products, went bankrupt upon the withdrawal of Federal funding. Among these were the futuristic Dymaxion House of Buckminster Fuller, and Carl Strandlund's porcelain enamel and steel Lustron Home. Other companies managed to profit from the very weakness of this Federal initiative; *Fortune* concluded,

> . . . the 1946 Wyatt program was almost entirely a private enterprise program, and a lot of private enterprises made a lot of money under its shelter.[17]

Operation Breakthrough

The next attempt by government and industry to infuse modern technology into the homebuilding sector came on May 9, 1969, when George Romney, Secretary of the U.S. Department of Housing and Urban Development, presented Operation Breakthrough. This proposal grew out of Section 108 of the Housing and Urban Development Act of 1968: "New Technologies in the Development of Housing for Low Income Families." The Section "authorized the (HUD) Secretary to select plans for the development of housing using new technologies, to construct at least 5,000 dwellings a year for five years using five different technologies, to evaluate the technologies, and to report the findings to Congress."[18] Ultimately, Operation Breakthrough exposed builders to the benefits of modern technology, and encouraged more uniformity within and between State building code systems; however, it failed to create widespread support for its programs in the American marketplace, where local factors tended to delay implementation.

Romney proposed a three-phase implementation of Operation Breakthrough: Phase I, Design and Development; Phase II, Prototype Completion; and Phase III, Volume Production. In June 1969, HUD requested proposals for the project. The department stated that:

> Operation Breakthrough has as its primary objective the establishment of a self-sustaining mechanism for rapid, volume production of market housing at progressively lower costs for people of all income levels.[19]

HUD received proposals from 236 firms. Commenting on the unexpectedly high response rate, one study observed:

> On the heels of the urban riots, many of the Nation's big corporations wanted to devote some of their money and skills to solving social problems—especially if money could be made at it. The list is long: American Cyanamid, General Electric, Inland Steel, CNA Insurance, Phillip Morris, Boise Cascade, Warner Communications . . . From every specialty, these wise kings came with their gifts to help the infant housing industry in its muddy manger.[20]

In February 1970, HUD selected 22 Operation Breakthrough finalists. Of the proposed housing systems, 10 were made of modular design, 9 were of panel design, and the remaining 3 used component assemblies. Initially, HUD selected 11 demonstration sites. Budgetary constraints later reduced the number to nine.

Operation Breakthrough lost its early momentum when the participants encountered costly delays in securing financing during Phases II and III. These delays, which arose from having to satisfy a multitude of local codes before a given design could be implemented, caused many financiers to lose interest in the program. In an effort to remedy the problem, HUD allowed Phase II and Phase III operations to proceed simultaneously, and "federal rent subsidies and section 236 subsidies were offered for Phase III units to speed production of Phase II prototypes."[21]

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[16] Ibid.

[17] "The Industry Capitalism Forgot," *Fortune*, 1947, vol. 36, No. 2, p. 67.

[18] John M. Quigley, "Residential Construction and Public Policy: A Progress Report," IBER Working Paper, Berkeley, CA, 1983.

[19] Ibid.

[20] Martin Mayer, *The Builders* (New York: W.W. Norton & Co., Inc., 1980).

The final blow to Operation Breakthrough came on January 16, 1973, when President Nixon announced an indefinite moratorium on new allocations of Section 236 subsidy funds. In the end, only 14 of the original 22 Operation Breakthrough participants built Phase III projects. Some housing producers did not participate due to the problem of code compliance. Others cited "cost and other production problems, corporate marketing policies, and bankruptcy" as reasons for avoiding the project.[22] Summing up the results of Operation Breakthrough, "about 25,000 Phase III units were completed in 150 different developments using Section 236 set asides. Only 1,500 units were completed for unsubsidized occupancy at market interest rates . . . No factory came close to completing a single volume run . . . The cost to the federal government was $72 million, or $12 million more than had initially been budgeted."[23]

While Operation Breakthrough is now looked on as a mismanaged Federal housing program, the effort did expose builders to new housing construction technologies. Furthermore, it led many States to reevaluate their building code systems, encouraged uniformity between State standards, fostered new methods for evaluating housing construction, tested new labor arrangements for structure assembly operations, and introduced American builders to innovative European practices. However, few HUD-sponsored building systems actually reduced the cost of housing as a result of the technology that came out of Operation Breakthrough.

After Operation Breakthrough

Since 1973, significant large-scale public, private, or joint venture projects encouraging the use of new homebuilding technologies have failed to materialize. While the "Joint Venture on Affordable Housing" initiated by HUD in several cities in 1982, has had limited success, most Federal efforts have related new technologies to energy consumption, not construction. The 1982 U.S. Comptroller General's report to Congress, "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs," cited a number of factors in government and industry that "impede the use of available technological innovation and the development and introduction of new ones."[24] These included:

- a low level of effort by the Department of Housing and Urban Development and the National Institute of Building Sciences to encourage the development and use of innovative technology, except for that related to reducing energy costs;
- builders' reluctance to accept risks associated with the use of technology whose long-term performance is not proven;
- restrictive and inconsistently administered local building codes; and
- builders' lack of technical information on the results of using innovative technology.[25]

The National Institute of Building Sciences had been created by Congress in 1974 under Public Law 93-383, and was intended:

> . . . to encourage all sectors of the building industry to develop a more efficient way of introducing technology into housing by encouraging a more rational building regulatory system through simplification and harmonization of building criteria, standards, and other technical provisions, and evaluating existing and new technology to facilitate its introduction and acceptance at the Federal, State, and local levels.[26]

Due to internal organizational problems, the National Institute of Building Sciences did not become fully operational until 1979. It has still not assumed the active role called for by the statute, primarily due to a shortage of financial resources.

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[21] Quigley, op. cit.

[22] U.S. General Accounting Office, Comptroller General, "Operation Breakthrough—Lessons Learned About Demonstrating New Technology," Washington, DC, 1976.

[23] Quigley, op. cit.

[24] U.S. General Accounting Office, Comptroller General, "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs," Washington, DC, 1982.

[25] Ibid.

[26] Ibid.

Summing up the scenario since Operation Breakthrough, the Comptroller General's 1982 report stated that "the statutory authority given to HUD and the National Institute of Building Sciences to encourage the development and use of innovative technology in homebuilding has been receiving only limited attention by HUD and the Institute."[27] Given the past performance records of both HUD and the Institute, it appears unlikely that either party will vigorously promote the research, development, or use of innovative technologies or materials to reduce housing costs, unless funds are earmarked specifically for this purpose.

The Future

Industry analysts generally agree that the postwar movement toward factory-built housing will continue, and may even expand. However, despite substantial interest on the part of leading industrial firms, as well as government backing for prefabricated housing under Presidents Truman and Nixon, large-scale mass production of homes in American factories has not materialized. Why should today's forecasts be more reliable than previous ones?

First, virtually all segments of the residential housing industry now depend on factory-based technologies to a certain degree. Until the Second World War, few firms were involved in mass producing houses, and a mere 0.5 percent of total housing construction was factory-built. Clearly, factory construction plays a more important role today.

Second, computer technologies are extending the inherent efficiency of factory-based production. Computers facilitate many individual operations involved in industrialized housing, from the initial design stage, to the building's final assembly. This improves quality control, saves time and money, encourages uniformity of parts, and enhances design flexibility. As new computer applications emerge and software is developed to meet the specific needs of the residential construction industry, factory-based technologies should become more attractive to homebuilders as well as homebuyers.

Third, the big builders are growing. The emergence of "superbuilders," and particularly the expansion of the largest firms among them (see table 3), has brought about the combination of capital and concentrated land markets necessary to justify long-term investments in plant and equipment. It is difficult to distinguish between cause and effect, because factory-based mass production, especially of the more profitable product lines, may also give firms a competitive edge to expand. In any case, some production builders have already indicated their intention to expand their production of housing, through continued acquisition of construction facilities.

Fourth, Japanese and European technological innovations, coupled with the growing threat of competition from foreign concerns acting in joint ventures with large domestic firms, has already inspired a combination of interest, emulation, and even fear within the industry.

Table 3.—Top 25 Homebuilders by Units Produced, 1983

1	Fleetwood Enterprises, Inc. (III)	37,746
2	U.S. Home Corp. (I,II,IV)	22,855
3	Champion Home Builders Co. (III)	21,715
4	The Commodore Corp. (II,III,IV)	16,274
5	Skyline Corp. (III)	16,118
6	City Investing Co. (I,III)	15,590
7	Redman Homes, Inc. (III)	15,403
8	Lincoln Property Co. (I)	12,734
9	Pulte Home Corp. (I)	12,008
10	The National Housing Partnership (I)	11,701
11	Tidwell Industries, Inc. (III)	11,010
12	Liberty Homes, Inc. (III)	10,565
13	Fairmont Homes, Inc. (III)	9,779
14	Kaufman & Broad Home Systems, Inc. (I,III)	9,570
15	Jim Walter Homes, Inc. (I)	8,706
16	Ryan Homes, Inc. (I)	8,503
17	Horton Homes, Inc. (III)	7,018
18	National Homes Corp. (II)	6,842
19	Cardinal Industries (IV)	6,754
20	Zimmer Corp. (III)	6,321
21	Canter Corp. (I)	6,299
22	Ocilla Industries, Inc. (III)	6,000
23	The Ryland Group, Inc. (I,II,IV)	5,491
24	Weyerhaeuser Real Estate Co. (I)	5,000
25	Conner Homes Corp. (III)	4,964
Top 25 total		295,686
Top 100 total		377,983
Top 25 as percent top 100		78

Legend:
(I) = production builder; (II) = panelized home manufacturer; (III) = mobile home manufacturer; (IV) = modular home manufacturer.

SOURCE: "Automation in Housing," 1984.

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[27] Ibid.

MARKET CONCENTRATION

The 1978-83 market share percentages, numbers of units produced, and sales volumes of the top 100 U.S. builders indicate the extent of market concentration within the residential construction industry. These 100 home producers captured 24 percent of the industrialized housing market in 1983, a decline of 2.7 percent from the 26.7 percent figure of 1982;[28] this can be attributed to the increasing presence of small builders in the revitalized housing market. Still, production levels and sales volumes for the top 100 builders increased between 1982 and 1983. *Automation in Housing* magazine's 1984 annual report indicated that "the largest U.S. firms accounted for 377,983 units in 1983. Their sales volume soared 35.7 percent to 12.019 billion compared with the 8.859 billion they put on the books in recession-battered 1982."[29]

Table 3 presents the top 25 homebuilders, ranked by number of units produced. The table also describes the product-types manufactured by each company. These 25 companies produced 78 percent of all units built by the top 100 homebuilders, and almost 20 percent of all housing produced in 1983. Ranking these companies according to their dollar volume of sales, the top five—U.S. Home Corp., Pulte Home Corp., Ryan Homes, Inc., City Investing Co., and Centex Corp.—all boasted 1983 sales in excess of $500 million; U.S. Home posted a sales volume of $932.7 million. Of these superbuilders, 29 had sales in excess of $100 million.

Implications for Small Builders

As the industry becomes more concentrated, the role of the small builder may change. New technology has the potential to drive out small builders, or at least to give them a different role. Use of factory-produced structural elements has already made the small builder more of an assembler than a craftsman. But it has also created many new opportunities for specialized firms, in areas like site preparation and crane operations. Will the small builder's future role be limited to pouring a foundation and assembling a set of modules or panels? Will the small builder become a captive of major production houses? Or will the small builder become an entrepreneurial specialist supplier to larger homebuilders?

"Manufactured" (Mobile) Homes

The "manufactured" (mobile) home industry is the most concentrated area of factory-based housing. Of the 169 firms engaged in the production of "manufactured" (mobile) home units in 1983, the top 25—as shown in table 4—accounted for 74 percent of the total production volume of 295,000 units. The top 10 companies produced 54 percent of all "manufactured" (mobile) homes, and the five leading manufacturers reported sales volumes greater than $250 million.

This oligopolistic industry structure has resulted from a series of mergers and acquisitions following the enactment of the Manufactured Home Construction and Safety Standards Acts. Many firms that could not comply with HUD's standards were acquired by larger "manufactured" (mobile) home producers. Table 4 also indicates that only 4 of the top 25 are private firms, the remainder being publicly traded corporations. Many of the public homebuilders have established mortgage banking subsidiaries to originate, underwrite, sell, and service home mortgages.

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[28] *Automation in Housing*, various issues.
[29] *Automation in Housing*, 1984.

Table 4.—The Nation's Top Producers of Mobile Homes

Company name	Headquarters address	1984 housing units
Champion Home Builders Co.[a]	Dryden, MI	22,795*
Fleetwood Enterprises, Inc.[b]	Riverside, CA	21,613*
The Commodore Corp.[c]	Syracuse, IN	20,580*
Skyline Corp.[d]	Elkhart, IN	16,892*
Redman Homes, Inc.[e]	Dallas, TX	15,732
Guerdon Industries, Inc.[f]	Denver, CO	13,000
Liberty Homes, Inc.	Goshen, IN	12,075
Fairmont Homes, Inc.[g]	Nappanee, IN	11,815*
U.S. Home Manufactured Housing Corp.[h]	Houston, TX	10,179*
Tidwell Industries, Inc.[i]	Haleyville, AL	9,636*
Zimmer Corp.	Boca Raton, FL	8,500
Kaufman & Broad Home Systems, Inc.[j]	Los Angeles, CA	8,164*
Schulte Homes Corp.	Middlebury, IN	7,200
Horton Homes, Inc.[k]	Eadonton, GA	6,623
River Oaks Homes, Inc.[l]	Boaz, AL	6,000
Palm Habor Homes, Inc.	Dallas, TX	5,554
Conner Homes Corp.[m]	Newport, NC	5,460
Oakwood Homes Corp.[n]	Greensboro, NC	4,800*
Clayton Homes, Inc.	Knoxville, TN	4,489
DeRose Industries, Inc.	Indianapolis, IN	4,000
Wick Building Systems, Inc.[o]	Madison, WI	3,433
Winston Homes, Inc.[p]	Double Springs, AL	3,350
Golden West Homes[q]	Santa Ana, CA	3,250*
Fuqua Homes, Inc.[r]	Arlington, TX	3,018
Destiny Industries, Inc.	Moultrie, GA	3,000
Vintage Homes[s]	Atlanta, GA	2,880*
Home of Merit, Inc.	Bartow, FL	2,702

*Figure estimated by RED BOOK editor.

[a] Firm also produces motor homes.

[b] Firm also produces travel trailers and motor homes.

[c] Firm is a publicly held corporation (Amex). Firm also manufactures modular/sectional and panelized units as well as commercial mobile units.

[d] Firm also manufacturers travel trailers and mini-motor recreational vehicles.

[e] Firm is a subsidiary of Redman Industries, Inc.

[f] Firm is a subsidiary of City Investing Co., New York, NY, as is Wood Brothers, Denver, CO, and General Development Corp. of Miami, FL.

[g] Firm also produces modular/sectional units.

[h] Two major subsidiaries are Brigadier Homes (mobile homes) and Interstate Homes (modular/sectional homes). Centurion Homes is a subsidiary of Brigadier Homes.

[i] Firm also produces modular/sectional homes. Shelter Resources-Winston Industries was purchased by Tidwell Industries.

[j] Firm is a wholly owned subsidiary of Kaufman & Broad, Inc., Los Angeles, CA.

[k] Firm also produces modular/sectional units.

[l] Firm is a subsidiary of River Oaks Industries, Inc.

[m] Conner Homes Corp. acquired Breck Homes Inc. and Haverlock Homes Corp.

[n] Manufacturing conducted through Homes by Oakwood, Inc., a wholly owned subsidiary.

[o] Firm also manufactures panelized homes.

[p] Firm is a subsidiary of Tidwell Industries, Inc.

[q] Firm also produces modular/sectional homes.

[r] Firm is a subsidiary of Fuqua Industries, Inc., Atlanta, GA.

[s] Firm is a subsidiary of Vintage Enterprises.

SOURCE: Office of Technology Assessment.

Chapter 3

Consequences of the Shift to Industrialized Housing

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Consequences of the Shift to Industrialized Housing

How will increased factory construction affect the quality or cost of products for consumers, the structure of the construction industry, and industry employment? No fixed answers exist for these questions, since factory-based construction takes on a variety of forms. In Sweden, for example, factory production signifies quality housing using skilled craft workers in highly automated factories, while in the United States it often relates to low-quality units made by workers with few skills. The outcome hinges on the manufacturer's perception of market demand, and on the effects of public regulation.

EMPLOYMENT IMPACTS

Productivity

Above specific trends in the residential construction industry lies the question of overall productivity: is it going up or down, and how do we know?

Quantitative efforts to assess construction efficiency and productivity in the homebuilding industry resemble the guidelines used to analyze more conventional industries. This approach may be misleading, because conventional indices of economic performance, such as levels of "capitalization" and "value added by manufacture," do not always apply to the residential construction industry. As one economist explains, "the industry is diverse, dispersed, detached, and discontinuous—all characteristics which are viewed with dismay by analysts of more stable, highly-capitalized, conventionally-deployed industries."[1]

The diversity of the construction industry stems from the specialized nature of subcontracting units, which constitute over 70 percent of all construction establishments in the United States. This qualitative and geographic "unit spread" has resulted from an uneven distribution of consumer demand, labor markets, and availability of materials. Similarly, detachment of construction enterprises arises from diverse work movement patterns, the predominance of short-term subcontracting arrangements among different specialty firms, and the builders' continued reliance on a shifting array of building material and component suppliers. Finally, seasonal and annual fluctuations in consumer demand, material availability, and environmental conditions also account for discontinuity.

These characteristics reflect the housing industry's adaptation to the unpredictable social and economic forces that affect demand. However, the fact remains that the measured productivity of the construction industry has fallen in recent years. The Productivity Index, which measures changes in output per manhour, rose from 70 in 1947 to 110 in the mid-1960s, but it now stands at about 80. While no single consensus explains why new technologies have not increased productivity, several theories have been offered:

- The deflators used to adjust the value of buildings may not properly adjust for improved quality.
- Repair and maintenance may be underreported. Since the productivity of renovation work does not equal that of new construction, the overall productivity of the industry should fall as the ratio of renovation work to new construction increases. However, it is difficult to obtain accurate data on renovation. Because of the unclear ratio between these two activities, changes in their combined productivity are not easily interpreted.
- Increased uncertainty resulting from fluctuations in the demand for buildings has forced the industry to reduce the capital/labor ratio. Capital/labor ratios increased 4.2 percent per year

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[1] Francis T. Ventre, "Innovation in Residential Construction," *Technology Review*, vol. 11, 1979, pp. 51-59.

from 1950 to 1968, but declined by 0.8 percent per year from 1968 to 1974.[2]

- Large numbers of young, inexperienced workers entered the work force as the baby-boom generation came of age. Between 1968 and 1978, the number of 16- to 24-year-old workers increased from 15.3 percent of the construction work force to 24.2 percent. There has also been a significant rise in the number of new firms. The fraction of homebuilding firms less than 5 years old increased by a factor of 3 between 1960 and 1976.
- Levels of union participation and apprenticeship are falling.
- Offsite construction work, such as factory component construction, is not counted properly. The ratio of value added by the construction industry—the value of industry sales minus purchases from other industries—to gross output fell from 51.1 percent in 1958 to 44.6 percent in 1979.[3] In other words, a growing fraction of the value of homes sold was produced by suppliers to the industry, rather than by the industry itself. Also, between 1967 and 1973, 34 of the 41 industries that produced materials for the construction industry grew faster than the industry itself, and 23 grew twice as fast. The fastest growers made prefabricated wood components and structural wood members for residences, or items like wooden kitchen cabinets. Some of these firms outstripped the construction industry by a factor of 8. This suggests that factory productivity is higher than site productivity for many activities.
- There may be scale effects. Productivity was undoubtedly higher during the boom period of tract home construction.

While the U.S. housing industry may appear unproductive as a whole, it does employ a smaller fraction of the total work force than any other OECD nation, despite high U.S. construction rates. About 5.4 percent of American workers served the construction industry in 1980, compared with 11 percent in Japan, Italy, and The Netherlands, and 7 percent in France and the United Kingdom.[4]

This set of considerations does not explain recent patterns in construction productivity. Answers will arrive with better data.

Employment Levels

Given the annual fluctuation in housing demand and residential construction activity, accurate employment trends are difficult to project. Nevertheless, recent data on employment may help to examine labor requirements.

The U.S. Department of Labor estimated that 483,100 persons worked as general building contractors for residential buildings in 1983. Of this total, 346,100, or 72 percent, were classified as construction workers. The "manufactured" (mobile) home industry, according to the most recent *Annual Survey of Manufacturers* report, employed 42,000 persons in 1982, of which 34,600 were classified as production workers.

Detailed labor statistics on the panelized home, the modular home, and component manufacturers do not exist. However, the *Annual Survey of Manufacturers* does compile labor statistics for the prefabricated wood building industry,[5] which includes panelized homes, modular homes, and building components. While this industry classification also encompasses prefabricated structures, panels, and components for nonresidential uses, products for residential use comprise approximately 75 percent of all industry shipments. In 1982, employees in the prefabricated wood building industry numbered 16,800; 11,424 of these were classified as production workers.

Figure 7 illustrates employment trends for the general building contractor sector, and figure 8 provides time series employment data for the "manufactured" (mobile) home and prefabricated wood building industries. Both figures reveal that the last peak in employment levels for these employment classifications occurred in the late 1970s. Referring to figure 8, the decline in total employment in both the "manufactured" (mobile) home and the prefabricated wood buildings industries corresponds with an overall decrease in "manufactured" (mobile), modular, and panelized housing units produced between 1978 and 1982.

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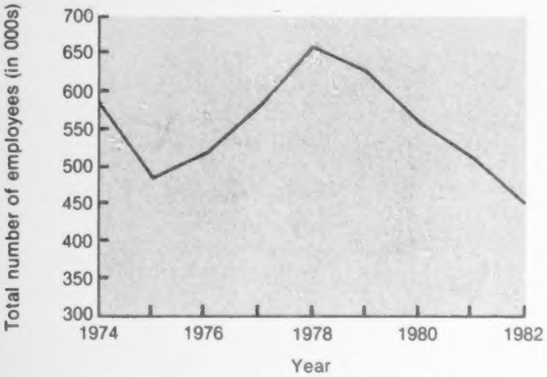
[2] H. Kemble Stokes, Jr., "An Examination of Productivity Decline in the Construction Industry," *The Review of Economics and Statistics*, vol. 63, No. 4, November 1981, pp. 495-502.

[3] J.E. Cremeans, "Productivity in the Construction Industry," *The Construction Review*, May/June 1981, pp. 4-6.

[4] Statistical Yearbook, United Nations, 1981 and 1983.

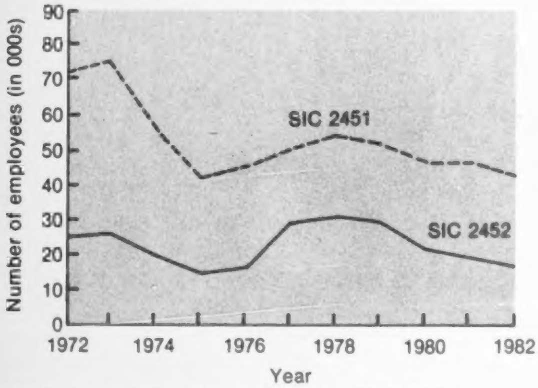
[5] SIC 2452.

Figure 7.—Residential Building Contractors



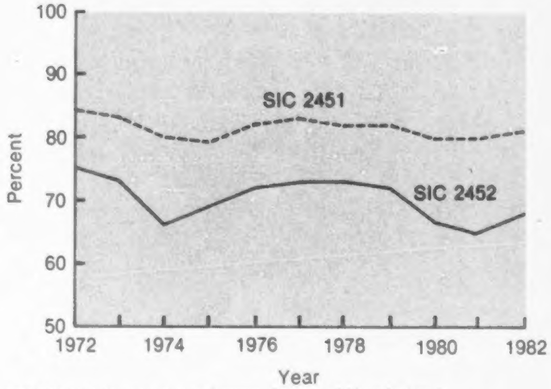
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

Figure 8.—Total Number of Employees in the Mobile Home Industry (SIC 2451) and the Prefabricated Wood Buildings Industry (SIC 2452)



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

Figure 9.—Production Workers as a Percent of Total Employment in the Mobile Home Industry (SIC 2451) and the Prefabricated Wood Buildings Industry (SIC 2452)



SOURCE: U.S. Bureau of the Census, Census of Manufacturers.

The proportion of production workers to all employees in the prefabricated wood building industry declined from 75 percent in 1967 to 68 percent in 1982. Production workers in the "manufactured" (mobile) home industry fell from 84 to 81 percent of the total work force between 1972 and 1982 (see figure 9). While some analysts attribute the increases in managerial positions to more government regulation, this development remains difficult to explain.

As for regional variation, when demand for new housing expands, firms compete for each others workers. This causes problems in the Northeast, where the number of potential employees is low. In contrast, an ample labor supply exists in the along the Mexican border, where many manufacturers employ alien workers; little skill is required, and the ability to read or write English is not of great importance. However, this creates problems of quality control, which, in turn, requires more supervisors.

Skill Levels and Unionization

Dependence on unskilled and semiskilled labor has been a motivating force in the shift to industrialized housing. One of the principal causes of industrialization is to reduce the ratio of labor costs to total product costs. Systematic, factory-controlled production processes allow manufacturers to train the labor force:

> . . . to repeat only certain tasks, and to repeat them under factory-supervised conditions. This task simplification means that any given worker need not be skilled in a trade, per se. Rather, the worker need only acquire skills necessary for the assigned task. When changes in unit design require a new set of tasks, workers are trained for the new tasks; no necessary, *a priori* generic and transferable skills are presumed.[6]

In other words, workers have neither need nor opportunity to acquire new skills.

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[6] Thomas E. Nutt-Powell, *Manufactured Homes: Making Sense of a Housing Opportunity* (Boston, MA: Auburn House Publishing Co., 1982).

Little data exist on skill levels, both because there has been no serious effort to collect the statistics, and as a result of the nature of labor requirements and the work force. To remedy the problem, in preparing this study, OTA project staff contacted 50 companies active in the industrialized housing and component industry. The resulting survey reveals the widespread use of unskilled or semiskilled workers in the component and "manufactured" (mobile) categories—approximately 80 percent of the work force (table 5).[7] Reliance on low-skilled workers stems from the fact that these products involve a great deal of simple assembly of cut-to-size parts.

The greater number of skilled workers in the modular sector—32 percent as opposed to 21 percent—stems from the more specialized tasks associated with modular units, such as plumbing, electrical work, and cabinet work. The higher percentage of college graduates in component and modular manufacturing may be design engineers. Typically, skilled workers in a "manufactured" (mobile) home plant perform tasks associated with chassis welding, plumbing, and electrical wiring. An average plant maintains a skilled worker in each trade area, who supervises the performance of unskilled, factory-trained workers. When skilled or semiskilled labor is required, some "manufactured" (mobile) and modular home producers hire on a fixed-fee, subcontracting basis. Using a subcontracted labor force, manufacturers do not pay overtime or provide worker benefit plans.

While the carpenter's union has contracts with a number of "manufactured" (mobile) housing firms, the industry as a whole lacks substantial union involvement. Production workers in the industrialized housing industry have relatively low skill levels. In addition to factory employees, the majority of workers who assemble panelized homes or work for large production builders do not belong to unions. Union affiliation in the residential construction industry has fallen steadily since World War II.

Even less unionization occurs in the "manufactured" (mobile) home industry. Possible explanations include: the small size of an average plant; the rural setting of most plants; the industry's slow beginnings; and the fact that the industry developed after the era of large-scale union organizing. When unionization does occur, it follows industry lines according to task-specific skill requirements and assembly line production methods.

Constrastingly, workers in site-built housing construction and onsite assembly of factory-built homes do tend to be affiliated with trade unions. One analyst asserts, "the managements of some firms with more than one manufacturing facility have made deliberate efforts to ensure that their plants, if unionized, are unionized by different unions."[8] This union fragmentation strategy reflects management efforts to control their bargaining position with the unions. The same writer believes that the classification of union members in the "manufactured" (mobile) home industry as assemblers, rather than on a job or craft basis, has allowed the "mobile home plant management to rearrange tasks and manpower as necessary to increase productivity, a major reason that labor in the mobile home industry shows higher productivity than conventional home building labor."[9]

Table 5.—Percentage of Work Force in Various Skill Categories

Group	Unskilled (less than 1 month)	Semiskilled (1-12 months)	Skilled: Not licensed/ certified	Skilled: Licensed/ certified	Skilled: College graduate
Component	38	41	12	1	8
"Mobile"	41	38	15	1	5
Modular	33	35	22	3	7

SOURCE: Office of Technology Assessment, 1986.

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[7] Two points about the data are worth noting. First, these numbers can shift as the market changes. Second, the firms that provided this data are a small fraction of the number of companies in the industry, but their average years in the business, 23 for component producers, 22 for "mobile" producers, and 19 for modular producers, would indicate their success, and confirms the credibility of the survey results.

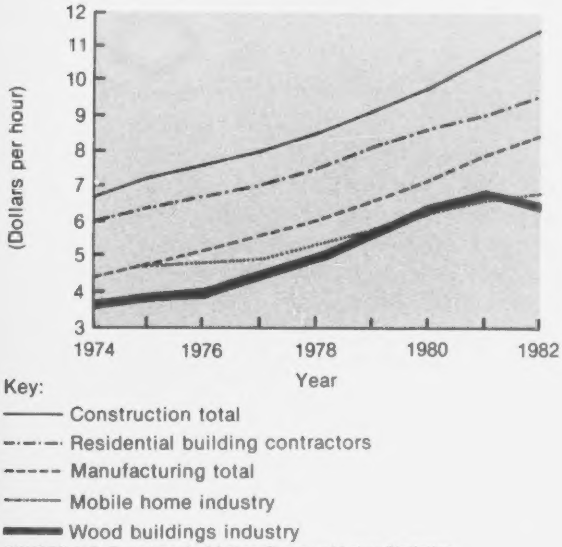
[8] Arthur D. Bernhardt, *Building Tomorrow: The Mobile/Manufactured Housing Industry* (Cambridge, MA: The MIT Press, 1980).

[9] Ibid.

Wage Levels

The housing construction industry's use of unskilled, non-unionized laborers has enabled the average "manufactured" (mobile), modular, and panelized home manufacturer to pay wage rates that fall below national construction industry averages. Figure 10 presents average hourly earnings for the respective housing construction and manufacturing establishments. Production workers in the "manufactured" (mobile) home and prefabricated wood building sectors have earned significantly less per hour than construction industry employees, and less than employees in the housing sector as a whole. Although general contractors have offered higher wage levels than the manufacturing sector, these wage levels do not equal those of the construction industry. Past trends suggest that wage level gaps between the various sectors will not close significantly in the near future.

Figure 10.—Average Hourly Earnings of Employees by Industry Sector



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

Potential To Upgrade Job Quality

To date, the U.S. industrialized housing industry has promoted "a clear shift from traditional 'craft' skills to industrial-type 'assembly' skills, even onsite. Some predict that craft skills will become part of a lucrative, but limited market for retrofit, conversion, rehabilitation, and historical preservation."[10] However, factory-based construction may not inevitably lead to the unskilled, routinized assembly-line. New technologies can create attractive, stable jobs for production workers. Employees in such facilities could be treated more like workers in automobile factories than day laborers, enjoying continuity of employment, skill acquisition, and identification with the employer or firm.

The Swedes employ factory-based construction to promote continuity in employment and to facilitate the development of an industry that provides greater returns to wages. Swedish factories resemble craft-based shops, where automated equipment amplifies individual skills. Rather than following an assembly line, Swedish factory workers craft individual structures using specially designed jigs and numerically controlled positioning, cutting, and milling systems. Whether U.S. industrialized housing producers will depart from current practice and opt for a Swedish-style approach will depend on economic and other factors that do not involve the technology itself, such as the status and potential for success of worker retraining programs.

HOUSING COSTS

Have new building technologies improved the industry's ability to lower housing costs? Unfortunately, examination of the existing data leads to ambiguous and contradictory results. With the exception of component fabrication, it is difficult to document the net economic advantages of factory-based construction in the United States, which is one reason that new technology has not entered U.S. markets more rapidly.

Homebuilding technologies most directly affect labor and material costs, which account for approximately 50 percent of total housing costs and which have risen at less than half the rate of land costs and financing[11] (see table 6). The extent to which cost savings in home construction will aid the homebuyer, and whether this will appear as increased profit for builders, will depend on the nature of local housing markets.

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[10] Eric Dluhosch, "Expert Panel on Technology Changes and Impacts on the Building Construction Industries," paper submitted to the Office of Technology Assessment, 1984 .

While precise cost comparisons are virtually impossible to construct, factory-built housing may lower costs by:

- increasing the labor productivity of construction with advanced assembly equipment,
- increasing the role of less-skilled employees willing to work for lower wages,
- decreasing construction time and construction loan costs,
- improving quality control with precision machinery and jigs,
- decreasing defects and site visits needed to repair such problems,
- reducing the seasonal nature of homebuilding, and
- facilitating the purchase of large volumes of materials.

New technologies also affect the 17 percent of total costs taken up by construction finance. Sharp reductions in the amount of time required to build a given unit—more so in the case of a multiunit project like a stacked modular—can save the factory-based builder substantial construction loan interest costs.

Construction time requirements for the various housing types depend on the building technologies employed, the skills of the workers involved, and management effectiveness. Table 7 presents construction time differentials for four types of housing.

Table 6.—Approximate Cost Breakdown for New Single-Family Homes

	1970		1980		Percent increase
	Cost	(%)	Cost	(%)	
Land	$ 4,450	19%	$15,500	24%	248%
Onsite labor	4,500	19	10,350	16	130
Materials	8,650	37	22,000	34	154
Financing	1,600	7	7,700	12	381
Overhead/profit	4,200	18	9,050	14	115
Total	$23,400	100%	$64,600	100%	176%

SOURCE: *The Report of the President's Commission on Housing*, 1982.

Table 7.—Construction Time Comparison

Structure type	Total assembly time
Double section mobile/ modular home	1 to 2 weeks
Panelized or precut home	6 to 8 weeks
Componentized home	4 to 12 weeks
Stick-built home	12 to 24 weeks

SOURCE: *Automation in Housing*.

As expected, an inverse relationship exists between the use of industrialized building techniques and components and the time required for construction.

To measure the extent that existing homebuilding technologies may reduce initial costs for the homebuyer, the National Association of Home Builders (NAHB) conducted a housing technology research project in 1979. The NAHB reported that its "cost buster" house achieved a 25-percent savings in construction material and labor, compared to other homes of similar size and location. Possible savings in construction finance costs were not considered. These cost savings will vary, depending on region; production levels; and the type, size, and quality of the housing.

To translate this 25 percent labor and material savings into an "overall" scheme, a 1982 report from the U.S. Comptroller General based a cost savings analysis on the National Association of Home Builders' data. Since labor and material costs constituted approximately half of the initial cost, a 25-percent reduction in labor and construction material expenditures decreases the sales price of a home by 11.75 percent, assuming that the cost savings are not retained as builder profits. Given the median price of a house in April 1981 at $69,300, the initial savings would total $8,143, assuming a conventional 30-year mortgage at 15 percent interest and a 20 percent downpayment. This would create monthly savings in financing costs of $82.41, or $29,668 over the 30-year mortgage period. Because land and financing constitute a growing share of construction and consumer housing cost, this is a high estimate of the cost reductions that may be brought about by existing technologies. Furthermore, the timelag between the introduction and use of new homebuilding technologies suggests that new technologies will not reduce housing costs in the immediate future.

Of the various forms and types of industrialized housing, "panelized and modular homes," the Comptroller General's report indicates, "are not a means of significant cost savings of new single-family detached housing. The industry markets the houses on the basis of their high quality, stemming from quality-controlled factory methods, and their advantages to small builders."[12] Although the base prices of panelized and modular homes do compare favorably with conventional construction, additional costs incurred in site acquisition, site development, and utility installation may reduce their affordability.

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[11] "The Report of the President's Commission on Housing," 1982.

However, panelized and modular homes can prove economical when site-building is simply not feasible—on scattered sites, or in outlying rural areas that lack skilled tradespersons. In addition, panelized and modular homes can yield savings in "soft costs" for builders. Since less site work is needed for these houses than for conventional site-building methods, builders can sell more houses with the same amount of finance money. Reduced work time at the site also negates losses from theft and vandalism.

The one type of factory-built house that does offer real savings in initial cost is the "manufactured" (mobile) home. Table 8 states that the average sales price of a "manufactured" (mobile) home in 1983 was less than 25 precent of that for site-built homes; however, sales figures for "manufactured" (mobile) homes do not include land costs and "setup" charges, which increase costs by at least 15 percent. Sales prices do reflect differences in product characteristics; while the average size of site-built homes has decreased in recent years, the typical site-built home remains larger than the "manufactured" (mobile) home.

Also included in the table is a time series cost comparison between "manufactured" (mobile) homes and site-built homes. Although the cost differential between "manufactured" (mobile) homes and site-built homes has increased over time, a cost calculation that included both the expected lifetime of each type of unit and the difference in maintenance costs would raise the effective price of the "manufactured" (mobile) units. As a 1985 report for the Department of Energy states: "Manufactured home occupants . . . consume more total energy per heated square foot than do occupants of other single-family detached homes"[13]—48 percent more from April 1980 to March 1981, and 31 percent more 2 years later. Furthermore, the Technical Advisor for Navy Housing recently concluded that when quality and upkeep costs are taken into account, "the mobile cannot compete economically."[14]

Table 8.—Cost and Size Comparisons of "Manufactured" (Mobile) Homes and Site-Built Homes Sold[a]

	1976	1977	1978	1979	1980	1981	1982	1983	1984
"Manufactured" (mobile) homes:									
Average sales price[a] (all lengths and widths)	$12,300	$14,200	$15,900	$17,600	$19,800	$19,900	$19,700	$21,000	$21,500
Average square footage	966	1,000	1,010	1,050	1,050	1,040	1,025	1,035	1,050
Cost per square foot[a]	12.73	14.20	15.74	16.76	18.85	19.13	19.22	20.29	20.48
Site-built homes:									
Average sales price[b]	$48,000	$54,200	$62,500	$71,800	$76,400	$83,000	$83,900	$89,800	$97,600
Average square footage (living space)	22.59	25.21	28.49	32.64	35.13	38.60	39.25	41.64	43.87
Cost per square foot[c]	1,700	1,720	1,755	1,760	1,740	1,720	1,710	1,725	1,780

[a] Includes furniture, draperies, carpeting, and appliances but excludes land as well as steps, foundation siding, anchoring, and other applicable setup charges (approximately 15% of home cost).
[b] Excludes all furnishings: includes land.
[c] Excludes furnishings, appliances, and land.

SOURCE: Manufactured Housing Institute.

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[12] U.S. General Accounting Office, Comptroller General, "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs," Washington, DC, 1982.

[13] Pacific Northwest Laboratory, "Impact of Alternative Residential Energy Standards," November 1985, p. 3.3.

[14] Richard Hibbert, U.S. Navy, correspondence dated Mar. 6, 1986.

HOUSING QUALITY

Objective measures of quality in housing are difficult to construct. The "satisfaction" rating for both site-built and "manufactured" (mobile) housing has increased steadily during the past decade. In a 1983 Department of Census survey, 60 percent of the respondents living in site-built homes constructed in 1976 rated their house as "excellent," and 80 percent of respondents living in a house built in 1983 gave their homes the same rating. For "manufactured" (mobile) homes, "excellent" ratings were given by 30 percent in 1976 and 54.6 percent in 1983.[15] Table 9 compares site-built and "manufactured" (mobile) homes from two different periods. While newer units fared better than older units in most cases, the site-built units were less likely to suffer from any of the defects surveyed. Also, other defects, including inoperative doors and windows, leaky pipes, and electrical wiring problems, have increased substantially in newer "manufactured" (mobile) homes.[16]

In an effort to determine whether these reported defects did exist, the RADCO company made several site inspections of units that had been the subject of a previous survey. One or more major problems were discovered in three of every four units. Furthermore, field inspectors observed problems that had not been reported by homeowners in approximately 80 percent of the houses. Of the 520 problems identified in 81 homes, 30 percent were due to material defects, 30 percent to poor workmanship, 14 percent to problems occurring during unit setup, and the rest were the result of use or could not be determined.[17]

Table 9.—Percent of "Manufactured" (Mobile) and Site-Built Homes With Various Problems

	Built before 1977		Built after 1977	
	Manufactured	Site	Manufactured	Site
Holes in floor[a]	5.2	1.8	1.8	0.5
Peeling paint (currently)	1.4	3.9	0.8	0.4
Broken plaster (currently)	1.5	3.4	0.9	0.5
Units with nonworking outlets (currently)	2.3	3.6	2.0	1.2
Fuses or switches blown (in last 90 days)	15.8	17.3	16.4	18.1
Exposed wires (currently)	1.9	2.8	1.1	1.9
Heating breakdown	6.8	4.4	5.1	2.2
Roof leak[a]	21.9	6.8	20.0	3.6
Toilet breakdown (in last 90 days)	4.4	4.1	7.0	5.1
Holes or cracks in interior walls/ceilings (currently)	4.7	5.5	2.3	1.8

[a] Site-built home respondents were asked about "current" problems; manufactured home residents were asked about problems in the "past 12 months."

SOURCE: Westat, Inc., "Analysis of Annual Housing (AHS) Data Pertaining to the Durability of Manufactured Housing," February 1986, p. 4-3.

The relatively poor performance of the "manufactured" (mobile) units just cited does not stem from factory production technique. More likely, it reflects the U.S. market for low-cost/low-quality housing. There is no direct equivalent to a "manufactured" (mobile) home in Europe or Japan.

Factory-based technologies can enhance the physical and esthetic quality of housing. In the United States, the term "prefab" still calls to mind inexpensive, monotonous, and drab housing. Consumers tend to believe that American factories produce dreary, shoddy homes. However, the high-quality, high-status houses constructed in Swedish plants prove that factory construction can offer significant advantages at various stages in the homebuilding process, from the initial design phase through the production, assembly, and erection of the end product.

Common stereotypes notwithstanding, the U.S. industrialized housing community has met consumer demand with the development, through basic engineering procedures, of various housing configurations. Units mimic the styling array of conventional "stick" builders: one-story, two-story, split-level, exposed ranch, contemporary, and traditional. They feature varied foundation systems, roof configurations, fenestration, and floor plans.

In certain cases, particular features are limited. For example, while 24-inch stud spacing has proven sufficient for most homes, the interior sheathing used in some industrialized housing is too thin to span this distance and still remain flat. On the whole, however, many options are available to the consumer of industrialized housing. Component and modular manufacturers produce up to 1,000 different models to choose from, and provide custom design options for high-income buyers.

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[15] Westat, Inc., "Analysis of Annual Housing (AHS) Data Pertaining to the Durability of Manufactured Housing," February 1986, pp. 4-10.

[16] Ibid., pp. 3-17, 3-18, 3-23.

[17] Resources, Applications, Designs & Controls, Inc. (RADCO), "Final Report for Durability in Manufactured Homes," December 1985.

Improvements in computer-assisted design (CAD) should enhance design flexibility still further. Prospective homebuyers may now design their own floor plans, and compare different interior and exterior wall coverings in the unit spaces. The Japanese connect this process directly to production equipment, which then deliver pre-assembled units to a construction site within 3 weeks.

Concerning the manufacture of component parts, the factory setting offers the efficiencies of mass production so that structural components—such as floors, roofs, windows, and doors—can meet uniform tolerances. The high quality of prefabricated building components has contributed to their acceptance by many State and local building codes. Component manufacturers confront markets that can absorb high volumes of production, which helps to offset the fixed costs associated with automated manufacturing equipment.

Factory construction means that homes can be built to more precise standards, and can benefit from more reliable assembly. Onsite construction and assembly work is vulnerable to the vagaries of weather, and workers may cut corners—especially when a layer of drywall and paint will cover a multitude of sins. The incentive and opportunity to do this is reduced in the factory. In Sweden, the resulting quality is such that most firms offer 10-year guarantees on their products.

U.S. manufacturers have only begun to implement technologies that are already realized in Swedish and Japanese industrialized housing. Still, certain advantages of factory construction involve quality improvements that would not be readily accepted by contemporary American markets. Some industry analysts believe that this problem may be solved through a system of rating or labeling houses according to graduations of quality (see ch. 6). Finally, recent improvements in the design and manufacture of commercial structures should affect residential construction, over time.

Chapter 4

Industrialized Housing in Japan, Western Europe, and Canada

Chapter 4

Industrialized Housing in Japan, Western Europe, and Canada[1]

Despite the growth of factory-based housing in the United States and the American tradition as an innovator of mass-production technology, other industrialized nations top the United States in terms of homebuilding technologies. U.S. firms can learn much from foreign developments.

The sophisticated manufacturing facilities of foreign housing industries constitute the major difference between U.S. and foreign firms. Most American plants lack modern equipment, relying on unskilled laborers and worker-operated machines. Skilled operators and high-speed assembly lines make Scandinavian factories more capital-intensive, especially those in Sweden. Some Japanese companies have automated to the point where they employ robotics and computer controls for production. The Japanese are beginning to market homes through "showrooms" that provide customers with an enormous range of design options.

Japan, Sweden, and other Western European nations now see the United States as a major market for manufactured housing. Foreign penetration, which was unthinkable just a few years ago, has now raised considerable concern and debate within the industry. At the same time, some members of the U.S. industry believe that the existing domestic approach can satisfy American market demand, and negate the potential of foreign investment in research and development. One observer of the U.S. "manufactured" (mobile) home industry contends that the Japanese and Europeans are "obsessed" with technology.[2] The vice-president of one of the largest firms in the United States visited a construction research facility in Japan and asserted that "he could not believe all these [research] employees just running wild" and that "if he were head of Taisei he would fire every one of the R&D staff and save the company $25 million per year."[3] However, other observers argue that the U.S. industry has grown complacent with the assumption that construction is a "nontraded" commodity. They fear that the lack of U.S. research and development robs American homebuyers of both qualitative improvements and cost reductions, and increases the opportunity for foreign producers to penetrate markets.[4]

In order to assess the potential impact of foreign competition, as well as to provide some points of comparison with the U.S. housing industry, this chapter examines industrialized housing in nine selected countries. Also, it will address a range of domestic and international factors that affect foreign penetration of the U.S. housing market.

Photo credit: Don O. Carlson

An American manufacturing facility. Workers glue panels by hand, rather than with automated techniques.

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[1] Unless otherwise noted, the material in this chapter is based on research conducted by the Stephen Winter Associates, New York, N.Y.

[2] Arthur D. Bernhardt, *Building Tomorrow: The Mobile/Manufactured Housing Industry* (Cambridge, MA: The MIT Press, 1980).

[3] Albus Trip Report, July 7, 1985, cited in Daniel W. Halpin, Final Report Task 3, "Technology in Architecture, Engineering, and Construction," contractor report for the Office of Technology Assessment, Mar. 17, 1986.

[4] See for example the article by Don Carlson in *Technology and the Future of the U.S. Construction Industry* (AIA Press, 1986).

JAPAN

Japan's housing construction industry is based on high-volume concentration in a small number of firms, design flexibility, and capital-intensive, high-technology production. Table 10 summarizes the characteristics of Japan's five largest business enterprises, which as a group produced 56,000 units of industrialized housing in 1983. Several of these firms, including Matsuchita, Asahi, and Sekisui, own stock in housing companies. Misawa spent 1.5 percent, or $7.5 million, of its 1984 sales on research. Sekisui spent 0.2 percent, or $2.5 million.[5]

However, the 170,000 factory-built homes that are sold each year represent 15 percent of the Japanese housing market (see table 11). Most houses are still produced by traditional "post-and-beam" frame methods; a small number, about 7 percent, are multifamily structures or are built with American 2 by 4 inch wood stud techniques.

Several large corporations control home manufacturing: Misawa, Daiwa, National Homes, Sekisui Heim, and Sekisui Chemical. These five companies account for 86 percent of Japan's total production. Their factories are highly automated, using such modern equipment as robotic welders and mainframe computers. Each plant can produce thousands of units per year.

Many of these houses are wood-framed modulars with walls constructed on a wooden lattice, rather than with the stud wall construction employed in American modulars. Building elements, such as walls and floors, are assembled into small modules in the factory and trucked to the site. These modules often lack the factory finish of an American modular.

The one notable exception to the wooden lattice system is the precastle autoclaved lightweight ceramic (PALC) system, developed by Misawa Homes with extensive funding from the Japanese Government. Modulars of this material, which resembles European lightweight concrete, contain a homogeneous envelope that functions as structure, insulation, fireproofing, and interior/exterior finish. Currently, Misawa produces this type of house in only 1 of 23 plants, but claims that PALC units require just 170 man-hours to construct—as opposed to 3,300 man-hours for standard "post-in-beam" techniques, or 1,000 man-hours for pre-stressed wooden panel systems. This represents an extraordinary gain in productivity.[6]

Misawa has developed elaborate equipment for fabricating these insulated wall panels with a variety of interior and exterior finishes, and has engineered automated devices to fabricate panels con-

Table 10.—Comparison of the Top Five Factory Housing Companies in Japan, 1983

Rank by production	1. Sekisui House	2. Misawa Homes	3. Daiwa House	4. National House	5. Sekisui Chemical
Total production (83)	40,436	30,650	20,794	20,444	12,237
Year founded	1960	1962	1955	1963	1947
Factories producing housing	4	22	12	4	6
Total employees	8,014	1,105	5,672	2,010	6,038
Total assets (million yen)	597,497	138,208	289,198	69,346	290,937
Equity ratio	26.7	20.0	34.0	25.2	18.0
Major shareholder (percent owned)	Sekisui Chem (20.3)	Misawa Co. (9.6)	—	Matsushita (58.6)	Asahi Chem. (16.2)
Ownership by Japanese banks (%)	13.4	10.4	14.9	6.7	8.6
Foreign ownership (%)	12.8	11.3	15.8	6.0	10.3
Sales breakdown (%)					
Building materials	—	69	87	63	—
Housing construction	79	—	—	27	38
Other construction	—	13	—	—	—
Housing lots	—	—	—	10	—
Real estate	21	—	13	—	—
Other activities	—	18	—	—	68
Sales—March 1984 (million yen)	443,742 (Jan. 84)	126,216	285,689	97,924	324,018

SOURCE: Japan Company Handbook, First Section Firms, First Hall 1984, The Oriental Economist, cited in James McKeller, "Industrialized Housing: The Japanese Experience," Alberta Department of Housing, December 1985, p. 81.

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[5] James McKeller, "Industrialized Housing: The Japanese Experience," Alberta Department of Housing, December 1985, p. 95.

[6] Ibid.

Table 11.—Factory Home Construction in Japan (as a percent of all home construction)

1971	8.5
1975	10.9
1979	10.8
1980	12.6
1981	13.6
1982	14.4
1983	15.3

SOURCE: Building Center of Japan, 1984. Cited in James McKeller, "Industrialized Housing: The Japanese Experience," Alberta Department of Housing, December 1985, p. 76.

structed from 1- by 4-inch "studs" and thin plywood sheets.

Most Japanese prefabricated homebuilders maintain sales offices throughout the country. In 1980, for example, Misawa sold 13,000 units through franchise dealers, employing 1,700 sales personnel in 163 branch offices. Manufacturers sell through "home show parks," where model homes of many different firms appear in the prime retail locations of major cities. Accordingly, land costs represent a major investment. The Sendai Park, located on the site of Osaka World Fair, shows 48 homes and is the largest such facility. The Tokyo Housing Fair displays homes in Shinjuku. The Asahi Broadcasting Co. operates both of these home show parks, charging approximately $7,000 per month for each house; the fee covers land, management, and advertising.

After viewing these displays, the prospective homebuyer can, with the help of an architect, custom design his house using a simple CAD (computer-assisted design) system. Upon completion of the design, a materials list is generated instantaneously. The buyer then receives a price, and the order goes to the factory.

Widespread export of Japanese industrialized housing or manufacturing technology has not occurred. Misawa plans to construct a PALC plant in South Korea, and intends to arrive in the United States within the next several years. All of the major manufacturers have expressed an interest in the U.S. market. They would welcome joint ventures, but do not wish to commit to large-scale investments. Daiwa is employing conventional U.S. technology in Houston and California, perhaps to learn the market before making a significant capital expenditure. Misawa has entered into an "agreement" with U.S. Home, but the details have not been revealed.

Japan may need to modify its products in order to penetrate foreign markets. Aside from differences in taste, Japanese domestic markets emphasize fire-resistance and the ability to withstand earthquake tremors to a greater extent than U.S. markets. Energy efficiency receives little attention, due to the mild Japanese climate; few Japanese residences have central heating.

SWEDEN

The Swedish industrialized housing industry may be the most highly developed in the world. In the mid-1960s, Sweden set a national goal of building 1 million new homes in a decade. This goal was achieved by reorienting the nation's homebuilding industry around factory production, and the trend continues today. Following the initial 10-year period, 40 percent of all single-family homes were produced in factories. By 1983, that figure had risen to nearly 90 percent (see table 12). The Swedes maintain exceptionally high standards of quality, and offer multiyear guarantees for parts and workmanship.[7]

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[7] For a recent review of developments in Swedish manufactured housing see L. Schipper, S. Meyer, and H. Kelly, *Coming In From the Cold: Energy-Wise Housing in Sweden* (Cabin John, MD: Seven Locks Press, 1985).

Table 12.—Factory Construction of Single-Family Homes in Sweden (as a percent of all single-family home construction)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Factory built (%)	60	55	55	43	42	48	44	49	49	58	65	82	89
Site built (%)	40	45	45	57	58	52	56	51	51	42	35	18	11
Total units (thousands)	35.7	42.8	43.2	53.3	36.1	42.7	40.2	40.6	38.2	32.6	26.8	23.4	19.3

NOTE: "Factory built" means produced substantially or entirely from factory elements. "Site built" means produced principally from loose wooden elements on site. The sharp increase in construction in 1974 resulted from a rush to take advantage of a tax rebate program before it expired.

SOURCE: Central Bureau of Statistics, Construction and Housing Loan Statistics, Stockholm.

Of the approximately 55 Swedish industrialized housing companies, 12 are considered to be "large." Building systems include small and large wood-framed, highly insulated panels, which may be handled by either workmen or a small crane. Factory techniques represent the state of the art. Typically, computer controls operate factory production lines, allowing for flexibility in the type of the units produced. Swedish houses incorporate many innovative technologies not in use in the United States; interestingly, some are produced by subsidiaries of American firms.

Swedish manufacturers export homes to West Germany, Austria, Switzerland, Holland, Norway, Denmark, Finland, the Middle East, and North Africa. The Swedes have begun shipping to the United States, on a limited scale. Swedish Wooden House has erected high-quality, energy-efficient housing in the United States for several years. Skanska, the major international construction and engineering firm, has entered the U.S. market in both commercial and residential construction. Also, as of March 1986, no fewer than 20 American corporations were engaged in importing Swedish houses, with a combined projected 1986 sales volume of 1,500 units. Nearly all plans to establish manufacturing facilities have grown out of joint ventures with Swedish factories.

Currently, an overcapacity exists in Swedish homebuilding factories, and production is at half its peak level. As a result, the Swedes may attempt to increase exports. The high-quality house represents the most likely product for the United States, erected with local custom builders in subdivisions of 10 or more units.

Sweden's dramatic progress in the housing sector has resulted from a broad national consensus and direct government policies. The government subsidizes mortgages, including costs related to energy and water conservation, and spends three times as much money on direct building research than the United States.[8] Including spending through universities and industry research, Sweden's total building research budget approaches $200 million per year.

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[8] Ibid.

FINLAND

Industrialized housing in Finland is widespread, including 60 percent of single-family homes built per year, although the Swedish industry is still greater. The predominant form employs the small panel, followed by units with large panels and modulars. Panelized systems may be closed in by the manufacturer, or delivered as kits to the owner/builder. Modular construction is also gaining popularity. As a whole, the residential construction industry enjoys an annual growth rate of 20 percent.

Finland's industrialized housing industry and its wood products industry are interrelated. Many firms produce the lumber and materials that will be used for individual home units.

The Finnish experience in exporting building materials like wood products and granite, the export orientation of Finland's economy, and its global placement of trade-oriented consular officials all place the country in a strong export position. Traditionally, trade has been with Africa and the Middle East, specializing in camp buildings. More recently, panelized homes and precut log houses have been exported to Great Britain, Sweden, South America, the United States, and—most of all—the Soviet Union. Finnish houses are found in 90 countries. Makroscan USA, a subsidiary of Makrotalo Oy, one of the eight large house manufacturers in Finland, and MakroEngineering, a manufacturer of house-factory equipment, are currently finishing a project in Massachusetts. They now seek builders interested in using their system, as well as other joint manufacturing ventures. Also, they sell factory equipment.

DENMARK

The Danish industrialized housing industry aims for both domestic and export markets. Nearly 80 percent of the detached housing produced since the mid-1960s has been factory-built, most of it panelized. At the same time, international contractors like A. Jespersen & Son and Larsen & Nielsen have constructed large projects throughout the world, primarily in the Middle East, using a prefabricated concrete system produced in local factories.

The small panel system, produced by such companies as Hosby Huse, Hellebo, and Roslev-Huse, represents the most likely export to the United States. Hosby Huse has already constructed a prototype unit at Brookhaven National Laboratory, the first in a cluster of energy-efficient houses from abroad.

CANADA

Canada's housing construction industry does not compare to that of the United States, basically due to the small Canadian housing market—150,000 units per year. However, Canadian manufacturers have experience in exporting precut, panelized, and modular building systems, especially Viceroy, Britco, and Freure Homes. Viceroy sold 1,200 of its precut home packages in 1984, and topped that a year later. The firm now plans to expand aggressively in North American markets, and expects to establish manufacturing facilities in Florida and Canada. Viceroy credits its success to both outstanding design and the high quality of their materials.

Some industry members believe that despite shrinking demand, the market share for industrialized housing will increase as Canadian housing construction shifts from large developments, where there is an economic advantage to site building, to dispersed rural housing. Factory-produced homes should have a cost advantage over site-built houses erected by small rural builders.

Housing exports from Canada to the United States may increase rapidly in the near future. Most Canadian housing factories are situated near population centers, within range of the United States. One American inspection and certification agency has already been contacted by five Canadian manufacturers about exporting homes to the Northeastern States. The relative strength of the U.S. dollar has served as an economic advantage, generating low shipping costs.

GREAT BRITAIN

For over a century, the British have led in design and construction of industrialized buildings. They shipped prefabricated schools and commercial buildings to the Middle East, Africa, and Asia long before many of today's large firms entered these markets. Most British building systems rely on metal framing, given the domestic shortage of construction lumber.

British real estate investors have been active in the major U.S. cities for some time, and British companies have entered the U.S. housing market by using traditional building techniques. Britain's Barratt Homes, which last year built approximately 11.5 percent of Britain's private housing, has established an American subsidiary, and hopes to complete 4,000 to 5,000 homes annually during the next few years. Another British firm, John Laing Homes, now operates in southern California. Laing plans to complete 200 units in 1986, and 1,000 units a year thereafter.

FRANCE

Along with the British, French firms have been among the top five international contractor groups for many years. Recently, several French companies have entered U.S. markets as real estate investors and developers. For example, Les Nouveaux Constructeurs produces conventionally built housing in Los Angeles, and expects to complete 300 homes per year by 1988 and 500 by 1990. The firm's management believed that California had a stronger and more sustainable economic base than other areas of the United States.

In a joint venture with U.S. Home, Maison Phenix has built a limited amount of steel and concrete housing in Florida. Also,Fillod has attempted to sell French-designed metal-framed housing and commercial buildings.

NORWAY

Traditionally, Norwegian contracting firms have been active in the Middle East, Africa, and Malaysia. Sandegruppen A/S, the largest group of contractors in Norway, now operates in the Orlando, Florida, area as the Selmar Corp. Selmar will construct the Norwegian Pavilion at Disney World's EPCOT Center, and also has plans for conventionally built condominiums and townhouses in the Orlando area.

At least one other Norwegian homebuilder, G. Black Watne A/S, currently operates in the United States, in the Austin, Texas, area.

WEST GERMANY

West German firms, like Phillip Holzmann AG and its subsidiary, the J.A. Jones Construction Co., have penetrated U.S. markets for nonresidential construction and development. The United States accounted for over $2 billion worth of contracts, or 41.7 percent of the foreign volume of West German firms in 1985, according to *Engineering News Record*.

Although internationally active in the production of factory-built housing, West German producers have not yet entered U.S. housing markets.

OTHERS

At the 1986 NAHB housebuilders show, firms exhibiting either housing systems or components included those mentioned above, as well as firms from Holland, Italy, and Belgium. Additionally, housing-related products from foreign sources—appliances, tiles, heating and cooling systems, and decorative items—were shown. Foreign exhibits accounted for approximately 15 percent of the total exhibit space.

Chapter 5

International Competition in Industrialized Buildings, Components, and Appliances

Chapter 5

International Competition in Industrialized Buildings, Components, and Appliances[1]

Penetration of the U.S. housing market by foreign building producers is not widespread, but is greater now than at any time in the past. A number of foreign manufacturers have decided that the potential gains outweigh the risks involved, and have entered the American market already; others plan to do so in the immediate future. Conversely, opportunities for U.S. penetration of overseas markets are, at best, limited.

During the last several years, foreign building system producers have expressed an increasing interest in the U.S. market. Evidence of this includes the substantial foreign presence at expositions like the National Association of Home Builders (NAHB) convention, the number of foreign housing manufacturers seeking U.S. building code approvals, and the actual number of foreign building projects under development in the United States.

Primarily, four factors explain this international competition:

1. a decreasing world building market, especially in the Middle East;
2. aggressive foreign pursuit of technological advances within the housing construction industry;
3. a greater interest in housing quality on the part of U.S. buyers; and
4. a decline of traditional markets to which foreign housing manufacturers export, and a corresponding excess in production capacity.

Foreign building products that may be exported to the United States fall in two distinct categories, systems and components. Building systems, described in chapter 2, constitute either the whole or the major elements of a building structure in prefabricated form, and include panelized, modular, "manufactured" (mobile), and wet core systems. Components, which do not fall within the scope of this report, are minor assemblies, subsystems, or elements like roof trusses, cabinets, appliances, equipment, building materials, hardware, fixtures, and accessories. In the long run, however, foreign producers will influence U.S. housing markets more through technology transfer than with sales of entire structures. Joint ventures with U.S. firms represent a probable vehicle for this transfer.

Currently, only a small number of foreign building systems exist in the American marketplace. However, component imports have increased substantially over the last 5 years, including roofing, hardware, steel and steel products, wood and wood products, kitchen and bath fixtures, appliances, heating and ventilating equipment, and a variety of decorative finishes and materials.

Market penetration by foreign building manufacturers could change rapidly in the near future. A number of manufacturers plan to export wood-framed panelized systems to the United States, upon completion of their market surveys and once building codes are approved. A case study comparing two Swedish systems with the Council of American Building Officials (CABO) Code for one- and two-family dwellings found that with minor changes, the two systems could satisfy U.S. statutes. Most of these changes stem from the fact that while Swedish codes are performance-based, CABO's—and most U.S. codes—are prescriptive. The arrival of other technologies, such as the Japanese ceramic house, does not seem imminent, but this may change with further technological development or market fluctuations.

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[1] Unless otherwise noted, the material in this chapter is based on research conducted by the Steven Winter Associates, New York, NY.

TRADE FACTORS AFFECTING EXPORTS TO THE UNITED STATES

Foreign building exports to the United States depend on the products' qualification as an acceptable building type, and also on market conditions, government policies and assistance, and related business strategies and decisions. These various conditions will affect the relative success of foreign products in the United States. Overseas manufacturers cite several incentives to risk penetrating U.S. markets.

Currency Exchange Rates

Fluctuations in the value of the dollar in relation to other currencies have, over the past decade, benefited foreign housing products. However, because component costs represent less than a third of the selling price of a house, changes in American tastes and expectations of quality may be just as important as changes in exchange rates.

Availability of New Markets

When compared to markets in most countries considering exports to the United States, the American housing market is enormous. Only Japan approaches the U.S. level, producing approximately 1 million units per year. As a result, the potential for new business is greater in the United States than elsewhere. The United States also holds various sectors, with opportunities for exploitation of specialized niches like vacation housing and condominiums.

Idle Plant Capacity and the Decline in Existing Markets

Companies that produced housing for the Middle East, North Africa, and developing nations have contended with a shrinking market in recent years. Reductions in oil prices and oil production, as well as the increasing Third World debt, have limited large-scale housing programs.

In addition, some foreign exporters project a decrease in domestic housing markets due to satisfaction of post-World War II demand. In the last several years, Sweden's domestic output has declined from 100,000 units per year to 40,000. Japan has also reduced demand for housing, through various 5-year plans. One observer believes that the Japanese will turn to renovation instead of construction, largly because of high land values and a shortage of building sites.

Against decreasing demand in many industrialized countries, companies that expanded production facilities now seek new markets. The United States may absorb much of this excess capacity. Third World markets are vast, but these nations cannot afford most available products.

Experience in International Trade

Foreign building manufacturers have significant experience in international trade. The typical Finnish housing manufacturer exports 50 to 70 percent of its housing production. Other Scandinavian firms export housing to the Middle East, North and Central Africa, the Soviet Union, South America, the Far East, and continental Europe.

FOREIGN GOVERNMENT POLICIES AFFECTING INTERNATIONAL TRADE IN HOUSING

Foreign government actions can have a large impact on exports from their countries. Many nations provide incentives and aids that are not available to American housing manufacturers.

Overall Strategies and Planning

In most industrialized countries, government and industry cooperate more than they do in the United States. The decision to export housing to the United States may be more than that of a profit-oriented firm seeking a new market; it may also reflect goals for the national economy, and for long-range industrial planning.

The current success of the Japanese housing industry has resulted from successive 5-year plans to achieve national goals in domestic housing. Development of such high-technology materials as ceramic wall panels was the direct result of the "House 55" research program, in which the Japanese Government funded advanced materials and systems research by leading Japanese companies. Pressure to increase domestic consumer spending may spur Japanese interest in supporting an innovative construction industry. The average size of a Japanese home was approximately 800 square feet in 1968, and 860 square feet in 1978; this is still less than half the size of an American home. Clearly, the Japanese cannot yet match Western standards of "adequate" housing.[2]

Market Information and Trade Representation

Many countries open their consulates and commercial attachés to domestic firms that intend to expand business prospects, another example of cooperation between the public and private sectors. The Swedish consulate in Chicago has familiarized Swedish firms with opportunities in the American market. The Danish consulate in New York has coordinated the export activities of manufacturers, and arranged for a multifirm booth at the 1985 NAHB exposition. The Finns maintain commercial attachés in New York and Houston; the latter office assists efforts to sell panelized housing to builders. The consulates of France, West Germany, and Canada have acted as conduits to channel market information back to manufactured housing exporters in their home countries. U.S. consulates could be used in similar ways.

Financial Assistance

Foreign governments support domestic builders in a manner unheard of in this country. This includes:

- low-interest loans to clients of domestic contractors or materials suppliers,
- project risk/profitability insurance,
- low-interest loans or tax benefits to contractors to erect projects in politically important areas,
- direct government-to-government loans that help to purchase products from the lender country,
- special tax incentives for export initiatives like market surveys, and
- performance bonding of domestic contractors.

Also, foreign governments channel aid so as to benefit builders. Following the 1980 Italian earthquake disaster, the United States sent relief money. European countries sent housing or supplies from their own markets, which both determined how aid would be spent and gave business to their own companies. In contrast, "Buy American" programs in the United States often fall short of their goals, as when the Army Corps of Engineers allows the use of non-U.S. materials for mechanical, electrical, and infrastructural subsystems.

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[2] James McKellar, "Industrialized Housing: The Japanese Experience," Alberta Department of Housing, December 1985.

IMPEDIMENTS TO MARKET PENETRATION

Obvious risks stand in the way of foreign housing manufacturers' attempts to export to the United States. Some are inherent in international trade, and others are peculiar to the practices of the U.S. building industry.

Changes in the International Market

Largely due to the currency exchange rate, foreign firms have had an advantage in the U.S. market. However, recent international monetary developments may leave these firms overextended. Some foreign manufacturers hope that other factors, such as product quality, will allow them to remain competitive in the U.S. marketplace. Others plan to adapt to changing currency rates by deemphasizing exports, instead establishing operations in the United States that resemble those of Japanese automobile and construction equipment manufacturers.

Lack of Understanding of American Markets

Foreign manufacturers of building elements come from smaller countries with more homogeneous populations, tastes, and climates than the Unites States. To understand the nature of a single market is a difficult task. The complexity increases when that market is composed of varying submarkets.

Producers may attack this problem by targeting specific market locations in the United States suitable for their products, based on such factors as climate and physical characteristics. This may mean the Northeast for Scandinavian insulated wood framed and finished panels, but southern California and Florida for Japanese ceramic panels, since these southern markets accept concrete and stucco-like products similar to the Japanese ceramics. Also, the ceramic material differs from traditional materials used in northern areas, and is unlikely to be accepted there.

Regional tastes, building traditions, and demographic trends also enter into consideration. This process worries foreign producers, who see the American market both as a great opportunity and as a place where they could go astray. A number of firms, including Norway's G. Block Watne in Texas, have built housing by conventional U.S. techniques, in order to become familiar with the U.S. housing industry before introducing their own technologies.

Lack of Knowledge of Optimal Business Relationships

Foreign producers are unfamiliar with the U.S. business world. Firms risk a great deal by entering into joint ventures, acquisitions, and the direct import of components. Some companies are forced into certain practices. For instance, if no U.S. firm agrees to a joint venture, the foreign firm confronts the market alone. A number of firms leave their options open, postponing major decisions and commitments until they familiarize themselves with the market. Demonstration "model" houses and small projects test the waters, displaying the system's feasibility and encouraging potential U.S. partners. Often, however, these isolated test market attempts have little impact, and do not provide adequate marketing information. Another strategy is the purchase of U.S. companies in order to acquire "in-house" market expertise, but this leads to difficulties in holding on to key personnel.

Difficulties in Locating Interested U.S. Firms

As opposed to other industrialized countries, the American building industry is decentralized. Japan has 5 large house manufacturing concerns, Finland has 8, and Sweden has 12. When these companies look for potential partners in the United States, they choose from hundreds of firms. The "right" partner is not easily found.

In addition, due to the decentralized building industry and to the small size of most firms, American companies often lack the available capital to contribute to a joint venture, although the limited joint venture between Phenix International and U.S. Home to build housing in Florida represents a prominent exception. The larger firms are not easily convinced that a joint venture is in their best interest; major U.S. manufacturers have not leaped at the opportunity to join with Danish firms. Generally, American companies look for monetary gain, not technological improvement. Also, there is a tendency in the American building industry to continue in accepted patterns, ignoring innovative procedures until they have been proven effective elsewhere.

Materials Acceptance Problems

Foreign housing manufacturers use materials and techniques that may seem strange to Americans. Exposed materials and structures, highly textured cementitious finishes, steel frames, concrete and metal roofing tiles, and ceramic panels are not well known, and may not be accepted in many parts of the United States. This problem stems from the variety of American markets. Typically, U.S. building markets have resisted new materials technology; many top U.S. firms that entered the housing market with innovative products, such as Boeing, U.S. Steel, and Alcoa, have given up this practice. These firms discovered that marketing houses differed from marketing other products. However, recent developments point to changing public tastes, primarily in urban areas where new architectural styles—"postmodernism," for example—have led to distinctive zero lot line and multifamily housing projects. In coming years, products now sought after as "high-tech" should become acceptable to the "trendy" marketplace.

Problems of Materials Testing and Acceptability of Foreign Standards

Building materials from abroad must comply with U.S. standards of fire safety, strength of materials, and durability, which apply to steel and wood framing, interior and exterior finishes, electrical and plumbing system elements, insulation, and other factors. Few foreign standards and test procedures demonstrate compliance with U.S. codes. Manufacturers will be forced to undertake extensive and costly materials testing in order to meet U.S. requirements. This represents an added deterrent, as well as a time delay, for the producer considering exports to this country.

Building Codes and Inspection Systems

Factory-produced building systems used in the United States must be approved by each local building official who has jurisdiction over a given project. They can also obtain the National Evaluation Service inspection offered by the model code agencies and their umbrella organization, CABO. The latter course of action works when the system is used widely and in different locations, but it requires a significant time and money commitment, and does not guarantee acceptance of the ruling in all jurisdictions. Furthermore, each factory must maintain its own quality control and inspection program.

Although European manufacturers view the multiplicity of U.S. codes as a major impediment, European firms have begun to study code procedures in the United States. Several Scandinavian panelized producers are now obtaining code approvals. The Japanese have also started to gain approvals for their systems under the U.S. codes; recently, Misawa Homes of Tokyo obtained approval for a wood lattice panel system. However, no large-scale effort is underway.

Trade Restrictions

Foreign manufacturers recognize that calls for protection from foreign penetration would rise with their increased presence in the U.S. market. Eventually, foreign manufacturers may submit to voluntary export limits, as has occurred within the Japanese automobile industry. Of course, foreign manufacturers could instead establish production facilities in the United States, either by buying U.S. firms or by creating a U.S. subsidiary. This would allow them to circumvent import quotas while maintaining profits from the U.S. market.

Lack of Understanding of Real Estate Markets

The housing market in the United States reflects not only the complexities of the house and its associated features, but also the intricacies of the real estate market. Foreign manufacturers could become involved in unprofitable projects, where failure stemmed not from the quality and suitability of their building system but from a lack of understanding of the local real estate market. In this area, many foreign firms seek American partners or consultants.

Liability

Many Europeans fear the problems of confronting the complex issue of liability in the United States. The possibility of being saddled with lawsuits concerning product liability, an area of U.S. law that is presently in a state of flux, worries foreign manufacturers.

Shipping Costs

Shipping costs represent the principle economic impediment to exporting housing to the United States. The cost of shipping a modular home from Europe or Asia to America is approximately $25,000, which precludes large-scale exportation of such products to this country. However, shipping costs are not prohibitive for more compact housing forms. One Scandinavian manufacturer estimates shipping costs for a panelized home at 6 to 12 percent of home materials costs, or 2 to 6 percent of total costs. Even after shipping costs, many products can be priced competitively in the United States due to cost advantages in production.

IMPORT POSSIBILITIES FOR VARIOUS BUILDING SYSTEM TYPES

Opportunities for exports to the United States of the generic types of building systems, described in chapter 2, will now be examined in detail.

Precut Systems

Precut housing systems, except for log homes and those from nearby Canadian manufacturers, are not easily imported to the United States. Wood-framed "stick" systems cannot compete, due to the high cost of imports as compared with available domestic systems. "Stick" systems would require expensive U.S. labor to assemble the building, and would create the logistical problem of shipping many small pieces.

These systems perhaps best illustrate which elements make a product suitable for import to the United States. Normally, the cost of the structural frame accounts for only 10 percent of the total house cost, and the house shell for only 30 percent. Building systems that supply only the materials for these elements cannot realize substantial savings, even if the cost of the materials falls below corresponding domestic levels.

In order to penetrate the U.S. market, an imported building system could focus on elements that require skilled workmanship, emphasize concentration of cost in the elements shipped, or bring out the visibility, styling, or refinement of the product.

Panelized Systems

Panelized systems represent the most likely type of foreign building systems to enter the United States, now and in the immediate future. Unlike modular units, panelized systems can be packed compactly against each other. The manufacturer does not pay to ship an excessive amount of empty space, because this type of cargo is usually shipped at a rate proportional to its volume.

Concrete Panels

Shipping of heavy concrete panels would not be cost-effective. These units can be produced in the United States at a lower price and are not used to any great extent for residential projects.

Lightweight cellular concrete panels may play a more important role in the future, due to their reduced weight and superior thermal performance. Again, however, domestic production would be less expensive.

Although no evidence exists regarding prior imports of concrete panels, a number of Scandinavian manufacturers, including Denmark's A. Jespersen & Son, have expressed an interest in selling forming equipment and technology.

Steel-Framed Panels

Currently, steel-framed composite panel systems are produced in Great Britain, Australia, West Germany, Finland, France, Belgium, and the United States. Intended for export—often for use in the construction of camp buildings, where large amounts of worker housing must be built rapidly—this framing system has advanced primarily in nations that lack either a large supply of lumber or a strong tradition of wood framing. A major French producer claims that steel-framed houses imported to the United States could sell for 20 percent below the cost of comparably sized, conventional American houses. Attempts are now being made to sell this system in the United States.

The use of steel framing for single-family housing has met with little success in this country, although lightweight steel studs have been used widely for interior partitions in multifamily units. Conventional single-family housing can be erected in a cost-effective manner with light gauge steel, but wood remains the market preference.

Steel framing or steel panels do satisfy the requirements of noncombustible construction, generally in buildings over three stories and in the metal building industry. Steel-clad insulated spandrel and curtain wall panels shipped from foreign countries can compete with equivalent U.S. products. Furthermore, increasing interest exists in steel-framed modulars for urban housing programs and for low-rise commercial office space.

Wood-Framed Panels

Wood-framed panels with integral foam plastic or mineral wool insulation resemble their U.S. counterparts, and are imported into the United States already. Given this market acceptance, expansion may soon occur. A common method for residential construction in Scandinavia—up to 60 percent of the single-family detached housing and 30 percent of the townhouses are panelized in Finland, and over 80 percent in Sweden—wood-framed panels have been exported in large numbers to the U.S.S.R., the Middle East, and North Africa.

Japan's manufactured housing industry contains a large wood-framed segment, but Japanse panels employ a lattice of smaller framing members rather than 2 by 4s, and are assembled into small modules before transportation to the site.

Wood-framed panels are relatively small, 4 to 16 feet by 8 feet, and can be handled and erected without equipment. Some manufacturers offer larger, custom-designed panels, which require a small crane for erection. The framing protects the edges of the panels, and the voids between the framing contain either foam plastic or fiberglass/mineral wool insulation. A continuous vapor barrier may be installed in the panel. Also, various surface finishes can be applied, such as plywood, fiber board paneling, and gypsum board.

Panels are used in the high-end residential market, where quality is a positive selling point, or in the low-end market of camp housing, since they can be easily assembled into modules. Imported wood-framed panel technology offers a number of advantages over conventional U.S. stick-built construction:

- high material quality and good craftsmanship;
- high levels of thermal insulation, up to R-37 in walls and R-47 in ceilings;
- adaptability to varying floor plans;
- higher degree of building tightness; and
- availability of sophisticated finish materials.

Spandrel Panels

Prefabricated metal spandrel panels, or curtain wall systems, are components, not building systems. As such, they are not part of this study's direct focus. However, they could become a significant import item. They contribute to facades of conventionally framed commercial buildings, and are currently imported to the United States from Italy, France, and Sweden. This foreign panel can fit easily into the U.S. market, since it does not involve changes in basic construction practice. European panels might replace American panels, although cost remains a consideration.

European Penetration of U.S. Panelized Systems Markets

Several European firms have entered or have expressed an interest in the U.S. market:

- Hosby of Denmark and Makroscan of Finland both exhibited panel systems in the United States, and desire to work with American builders. Hosby has built a model house to be evaluated for energy efficiency and technical advantages at Brookhaven National Laboratory in New York; Makroscan has built housing on Martha's Vineyard. The Hosby house received 4,000 visitors, including builders, architects, and potential homeowners, in its first weekend, and has averaged 400 visitors each weekend since then. This indicates substantial interest in Danish products.
- Phenix International and Fillod of France are active in this country already. Phenix has purchased 16 percent of U.S. Home, and has joint ventured in Florida. Fillod has built some steel-framed demonstration units, and markets its products through Modular Building Concepts, a New Jersey manufacturer.
- Such Swedish firms as Swedish Wooden House and Skanska, entered the U.S. market several years ago. At least six other Swedish firms have expressed an interest in expanding to the United States, and eight American importers of Swedish houses are now in operation. One hundred Swedish houses have been built in the Eastern United States, with 500 more expected by the end of 1986.
- Puutalo Oy of Finland and Norgips of Norway have also eyed the U.S. market, and Norgips has applied for model code approval. G. Block Watne of Norway is building in Austin, Texas.

At least 20 other major European firms export wood-framed panel systems to other countries, and may pursue the U.S. market. The most likely first step for any foreign producer would be to work with custom homebuilders and developers in this country, marketing the appeal of high-tech craftsmanship. Once the system is in limited use, expansion might then occur. Without joint ventures or direct sales, foreign producers will have to become developers in order to introduce their products.

Wet Core Modules/Control Centers

While complete modules are too expensive to ship internationally, the wet core module provides an exception. It can serve as the high-tech, high-cost center of the house, incorporating plumbing, service controls, laundry equipment, bathroom and kitchen fixtures, cabinets, appliances, and surface finishes. Such a module would overcome the problem of shipping empty space, due to its higher proportion of expensive materials and labor costs to space. To reduce costs further, the module could be shipped in a knocked-down state, with fixtures like bathtubs "nested" together during shipping and attached in their proper locations at the site.

Presently, nothing points to the exportation of large wet core modules, which incorporate whole rooms, in the near future. However, certain advances in kitchen cabinet design, planning, and packaging facilitate the export of smaller modules that form part of a room, incorporating a prefabricated plumbing tree and its associated fixtures. Also, cabinets are being integrated with kitchen appliances at the luxury end of the market. Admiral displayed an imported line of appliances, with cabinets produced at its Italian subsidiary, at this year's NAHB show. Other European appliance manufacturers that market in this country, including Maltritius and Gaggenau of West Germany, also integrate cabinets and appliances.

Japanese manufacturers are developing the "smart" kitchen, with electronic integration and control of the various kitchen appliances. A central processor controls all appliances, rather than each appliance having its own timer, regulator, and controls. Controls and monitors for other building systems, such as heating, air-conditioning, intercom/control/security, and lighting, may be centralized and incorporated into the wet core module as well.

The development of this centralized, capital-intensive building service and control center may overcome the prohibitive costs associated with shipping modules. If the cost/bulk ratio rises above a certain threshold, wet core/control modules may be cost-effective. Such a module would revolutionize standard building practice, bringing plumbing, fixtures, electronics, cabinetry, and appliances into one indivisible import package.

Modular Systems

Modular systems account for only a small share of world markets. Certain aspects of modular construction make it unsuitable for export to the United States. Generally, prohibitive shipping costs prevent export, although Afford-A-Homes, a Canadian company, does export a modular that "unfolds" into a 735-square-foot house, and can be shipped in an 8 by 9½ by 20 foot container; several U.S. firms have experimented with this concept. From Scandinavia, shipping can cost $80 per cubic meter, or roughly $18,000 for a 1,000-square-foot house. The high price pays primarily to ship empty space.

European modular prototypes may also be unsuitable for U.S. markets. However, the experience of European furniture exports indicates that foreign manufacturers will design products specifically for America.

Modular systems can be broken down into a number of different types:

1. *Concrete Modulars.*—Concrete modules are rare outside of the U.S.S.R. and Eastern Europe. They best suit highrise, repetitive "boxlike" apartment-type buildings that have proven uneconomical and unpopular in the United States and Western Europe.
2. *Wood and Steel Modulars.*—Generally assembled from panels, wood- and steel-framed modulars are used primarily for camp construction. Certain Scandinavian firms, such as Huure Ureeta Oy, have produced panel systems that can be assembled into modules in the plant or onsite.
3. *Ceramic Modulars.*—Recently, much attention has focused on "precastable autoclaved lightweight ceramics" (PALC). This material has resulted from extensive research by Misawa Homes of Japan, and is now incorporated into approximately 10 percent of Misawa's modular units. In essence, ceramics resemble the autoclaved, lightweight concrete that is manufactured in Europe. It differs from normal concrete by substituting air or gas bubbles for the aggregate in the mixture.

   However, the Japanese have taken the use of this material to a higher level. Whereas the Europeans fabricate lightweight concrete blocks and small panels, the Japanese produce large, steel-reinforced, framed panels, which are incorporated into modular units. This system relies on a homogeneous material that requires no additional finishing or thermal insulation, and provides structure, waterproofing, and fireproofing. Its competitiveness in the Japanese market derives from the supposedly low material and labor costs, although the role of government and corporate subsidy remains unclear.

   PALC is relatively new, and its full potential has not been realized. Claims that it is the material of the future should be examined closely. Less than 10,000 homes have been built with this technology in one Japanese plant, all in the past 3 years. This accounts for less than 0.3 percent of the Japanese housing market. And because it is an untested technology, no long-term studies exist on these houses or their performance. The Japanese, who see ceramic modulars as another high-tech item at which they excel and which they can export, give these systems widespread publicity. But the technology needs to gain greater recognition in Japan before it can enter the American marketplace.

   Except in Florida and California, where stucco-like materials dominate, U.S. market acceptance of single-family housing is problematic without dramatic cost savings. In the case of PALC, this appears unlikely. Historically, materials that enter the conservative U.S. housing market, such as hardboard, aluminum, and vinyl siding, have simulated familiar materials like horizontal siding or tongue and groove vertical wood siding. As a rule, other types of panels have not been accepted by the domestic housing industry, which believes that prefabricated homes should appear otherwise. This technology would suit multifamily housing or commercial building, but only if it represented a cost-effective solution.

   This material has received much publicity in the United States, and many U.S. delegations have been encouraged to visit the Misawa plant. However, these plant visits appear to be more of a "sales pitch" than a technical exchange. PALC represents an interesting alternative, but final judgment should await an analysis of its suitability for U.S. markets.

"Manufactured" (Mobile) Home Systems

U.S.-type "manufactured" (mobile) homes are rare in other countries, except as temporary or camp housing. However, the more advanced technological manufacturing systems of the Japanese and Scandinavians may produce salable and innovative models. Some observers believe that Japanese penetration of the U.S. market will occur in this untested area. The Japanese industrialized housing industry is geared towards high levels of production, which can satisfy the American "manufactured" (mobile) home market. In addition, the U.S. "manufactured" (mobile) home is under a preemptive national code, which makes it more attractive to a foreign manufacturer who intends to build production facilities in this country. A problem exists, however: in order to make up for the cost of new, sophisticated equipment, minimum sales would have to reach several thousands of units per year—not an easy target to achieve. But Japanese firms are willing to absorb initial losses in order to capture long-term markets. A joint venture with a U.S. firm would reduce risks significantly.

MANUFACTURING EQUIPMENT

Foreign building technologies may enter the U.S. market through a modification of standard American manufacturing and construction techniques, rather than through direct importation of building elements. A producer may begin by shipping building elements to this country. As demand for the products increases, it may become more cost-effective to produce them in the United States. Possible openings in this area include:

- *Panelization equipment, which foreign manufacturers will sell to U.S. homebuilders and manufacturers.*—These machines could vary from minor refinements of production line equipment at "manufactured" (mobile) home factories to sophisticated automated plants. A number of Scandinavian manufacturers have begun to market their equipment, but without a great deal of success.
- *Onsite forming equipment, produced by foreign companies such as Outinord of France, for use in onsite casting techniques.*—This equipment has been in the United States for 20 years, and would not require major outflows of capital.
- *Board fabrication equipment, such as cementitious fiber or particleboard, used in European construction but not commonly available in this country.*—Among others, Siempelkamp of West Germany exports complete fabrication facilities for such products.
- *Particleboard, flakeboard and oriented strandboard, originating in Canada, or made in the United States with Canadian equipment.*—This could replace American plywood.
- *Admixtures, used by European companies to produce lightweight cellular concrete.*—U.S. firms could manufacture this material domestically, through the use of such additives.
- *Heavy equipment, produced by such companies as Komatsu, the Tokyo-based construction equipment manufacturer ranked second next to Caterpillar.* Komatsu has announced plans to open its first U.S. assembly plant, which will avoid protectionist legislation. Their goal is to increase their U.S. market share from 7.5 to 20 percent.

FOREIGN INVESTMENT AND DEVELOPMENT

Foreign firms interested in penetrating the U.S. construction market may pursue a variety of financial options, rather than market foreign-produced buildings or components. This would provide insight into the complexities of the U.S. market, useful contacts and knowledge, and a reduced risk for the foreign producer.

Joint Ventures With U.S. Firms

Some foreign manufacturers have joint ventured already. In particular, the Japanese prefer this method, which combines Japanese production technology with an in-place American marketing and distribution network. Misawa Homes is seeking to co-venture with an east coast homebuilding firm, and Sekisui Heim is reported to be working with Cardinal Industries, a modular manufacturer. Also, Maison Phenix International of France entered into a joint venture relationship with U.S. Home in Florida several years ago, and Scandinavian firms have expressed an interest in such an undertaking.

Foreign panel manufacturers may begin their market penetration by exporting panels to this country, which would build market acceptance and create demand. Then, these manufacturers can joint venture or license with previously wary American firms, and produce their panels in U.S. factories. However, few of these products are so unique that the added overhead and labor cost of U.S. production would offset their current competitive advantage.

Mergers and Acquisitions

Foreign firms have pursued the increasingly popular option of the merger or acquisition, in order to gain a foothold in the U.S. market and to pick up useful experience:

- Holtzman AG of West Germany owns J.A. Jones of Charlotte, North Carolina, a contracting firm, and Lockwood Greene Engineers, a design firm;
- Skanska, the largest builder in Sweden, bought the Koch Steel Erecting Co. of New Jersey;
- Archirodon of Greece purchased George Fuller of New York, a firm that builds highrises;
- Alganin Industries of Kuwait bought Kirby Building Systems in 1975; recently, the American branch of the firm returned to U.S. owners;
- several American elevator companies are owned by foreign firms, including Haughton, by Schindler Holding of Switzerland, and Armor, by Kone of Finland; and
- the Clark Equipment Co. of Michigan has merged heavy equipment production with Volvo of Sweden, forming the third largest heavy equipment firm in the world.

Companies that acquire these firms may then compete for U.S. Army Corps of Engineers projects, under the "Buy American" program.

Foreign Development and Construction

Foreign developers, including Cadillac Fairview, Olympian, and York, have been involved in major urban projects for a number of years. More recently, European builders have developed housing projects in less urban areas of southern Florida and California. The British firms of Barrat Homes, Taylor Woodrow, and John Laing Homes are all active in this country, as well as the French firm of Premier Homes, a subsidiary of Les Nouveaux Constructeurs. Some of these companies started by acquiring established U.S. building firms. Several South Korean firms have expressed an interest in this area, but their asset of low-paid labor cannot be utilized in the United States, reducing their leverage.

APPLIANCES

While the United States enjoyed a favorable balance of trade in residential appliances for many years, foreign producers have begun to penetrate domestic markets with improved products and production technologies. Accounting for inflationary increases, U.S. exports of household appliances fell by approximately one-third between 1979 and 1984, while imports increased by over two-thirds.[3] This trend will continue, assuming that foreign manufacturers expand production.

U.S. exports of appliances have never been large; in 1983, U.S. firms exported about $990 million in appliances, or 0.5 percent of total output.[4] U.S. citizens stationed abroad purchase a significant fraction of these products. Japan, on the other hand, has expanded household appliance exports from $1.4 billion in 1979 to over $2.25 billion in 1983. Japanese appliances are widely available on the U.S. market, and Japanese companies invest heavily in new technologies. Whereas U.S. appliance manufacturers spend 1 or 2 percent of their sales on research and development, Japanese firms spend 4 to 7 percent.[5] Their efforts are beginning to pay off.

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[3] U.S. Department of Commerce, Bureau of the Census, EA 275, EA 675, SIC Code No. 363.

[4] The Stirling Hove Corp., Building Equipment Division "A Comparative Analysis of U.S. and Selected Foreign Household Appliance Industries," Department of Energy contract, October 1984.

Panasonic marketed a full line of products for 1985, some of which will be built in the Orient and some in Canada. Panasonic, Sanyo, and Daikon have captured 5 percent of the U.S. market for room air-conditioners by offering efficient, quiet units with rotary compressors. The units use 13 percent less energy than comparable U.S. products. Sanyo now imports small refrigerators—13 to 14 cubic feet—to the west coast, with an average energy consumption of approximately half that of the best U.S. models. They are beginning to offer "full-size" refrigerators in test markets,[6] and showed a full line of appliances at the NAHB exposition. The Japanese have introduced a number of innovations in refrigerators, including microprocessor temperature controls that maintain three to five compartments at different temperatures.

Some major U.S. appliance manufacturers have moved manufacturing operations abroad. General Electric, the largest domestic manufacturer of room air-conditioners, announced that it will phase out production at its main factory in Louisville, Kentucky, next year. Carrier has drastically curtailed production at its New York plants. The firms plan to purchase units assembled abroad, probably in Japan and Brazil.

At the high end of the market, European appliances are available in this country—from Maltritius and Gaggenau of West Germany, for example. These same manufacturers are working to integrate cabinets and appliances. Electrolux of Sweden owns Tappan in the United States and has acquired an Italian appliance subsidiary, making it one of the world's largest appliance manufacturers. They may attempt to sell European designs to American builders. Appliances such as range hoods may also come from Singapore and Korea.

Lighting and wiring equipment have become vulnerable to foreign competition as well. Between 1979 and 1984, accounting for inflation, U.S. exports in this sector increased by $50 million, or 3.5 percent, while imports rose by approximately $500 million, or 40 percent.[7] Japanese and German firms have taken the early lead in the development of innovative lighting products. Compact fluorescent lamps, compatible with standard "screw in" sockets, use one-third the electricity of a standard lamp, last 10 times as long, dump less heat into a room, and provide a light color that most people find more attractive than standard incandescents. Neither General Electric nor Sylvania, the largest U.S. lighting producers, manufacture these advanced products; rather, they offer foreign products under their own names.

As concern about indoor air quality increases, Americans may pay increased attention to home ventilation. The Swedes have invested heavily in equipment that ensures adequate air flow to each occupied room in a residence, while minimizing the heat or cooling lost in the process. Primarily, American houses rely on faulty workmanship to provide adequate ventilation, such as cracks around windows and doors and under sill plates. This guarantees that air enters the house, but rates of air exchange vary widely from house to house and with local weather conditions.

Only an active forced air system can ensure adequate ventilation. Both the French and the Swedes have developed inexpensive devices that control the amount of fresh air reaching each room in a home. The Swedes offer a variety of interior ventilation designs, including one which ventilates a home over the coils of a heat-pump water heater that extracts heat from the exhaust air. Their technical lead may put them in a position to enter U.S. markets rapidly, if demand for equipment to improve indoor air quality increases.

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[5] Howard Geller, "Energy Conservation R&D, Innovation, and Industrial Competitiveness: The Case of Household Technologies," ACEEE Background Paper, January 1986; Sterling Hove Corp., op. cit.

[6] Geller, op. cit.

[7] U.S. Department of Commerce, op. cit.

MATERIALS, COMPONENTS, AND EQUIPMENT

Foreign fixtures, building materials, appliances, and accessories are now exported to the United States, and may become more common. These items include:

- *Metal Roof Systems.*—A number of metal roofing producers have entered the U.S. market with roofing systems that imitate conventional materials like tile and slate, and suit both the single- and multi-family housing markets. Primarily, these systems come from Finland, France, and Sweden.
- *Plywood.*—Currently, high-grade Scandinavian plywood incorporates a number of plies and veneers not otherwise available in the United States.
- *Hardware.*—Much building hardware is imported from Europe. Two European manufacturers have built U.S. factories to reduce costs.
- *Door Frames.*—A metal door frame producer from Holland exhibited at the NAHB show, intending to export to the United States.
- *Elevators.*—In addition to purchases of American elevator companies by foreign firms, the Japanese manufacturer Fujitec has built a factory in Ohio.
- *Heat Pumps and Heat Exchangers.*—A number of Japanese manufacturers, including Mitsubishi, distribute residential heating and air handling equipment.
- *Cabinets.*—European kitchen cabinets have gained widespread use at the high end of the U.S. market. The European kitchen has become a new standard of elegance in American homes; domestic producers imitate European styling. Imported cabinets from West Germany, England, and Scandinavia are used by custom builders or are sold through kitchen dealerships, advanced through mass marketing or distribution systems. Soon, Korea may import inexpensive cabinets as well. These would enter the manufactured housing industry, where direct sales to manufacturers eliminate the need for an elaborate marketing and distribution network.
- *Plumbing Fixtures.*—Fixtures from Europe have been sold in the United States for some time, primarily from Scandinavia, France, Italy, and West Germany. Again, these custom items aim for the high end of the market.
- *Finishes.*—European plastic laminates are now distributed in the United States.
- *Floor Tile.*—Floor tiles from Mexico and Europe have been available to custom markets for many years.

Although building materials and fixtures lie beyond the scope of this report, their presence cannot be ignored when conducting research on building systems. The use of imported materials and fixtures is significant for several reasons: they can be incorporated into American buildings without disrupting standard American construction practices; they are subject to narrower testing requirements; they indicate foreign interest in penetrating the U.S. building market; and they provide an avenue for manufacturers to establish recognition and acceptance, from which they may advance the exportation of building systems or components.

IMPEDIMENTS TO U.S. PENETRATION OF OVERSEAS HOUSING MARKETS

U.S. international contractors, and industrialized housing manufacturers in particular, have witnessed diminishing overseas markets since the euphoric 1960s and early 1970s, when they operated in Iran, Saudi Arabia, and the Persian Gulf States. Today, these same major contractors service a reduced work load and few international housing projects, except for occasional "tag-along" housing components in a larger infrastructural or industrial project. The leading U.S. contractors, including Bechtel, Fluor, and

Blount, operate with as little as half the manpower of several years ago. Few analysts predict that the international building activity of the 1970s will resurface. Several reasons for the drop in international building activity are discussed below.

Increased Competition

Many new international contracting companies have assumed active, worldwide roles, especially in the Middle East, North Africa, Malaysia, and Indonesia. These include the aggressive European and Scandinavian firms, and also firms from Greece, Turkey, the Philippines, India, Taiwan, and South Korea.

Initially, the Koreans were encouraged by the U.S. Government. They have now become a dominant force, due to their organizational and technological sophistication. They also control the low-cost manpower that permits competitive bidding. However, even the Koreans are having difficulty now, as smaller projects allow for bidding by small local contractors with a fraction of the overhead of the major international—especially American—contractors.

Lack of Understanding of Foreign Markets

With the exception of established U.S. international contractors and a handful of housing manufacturers, such as ATCO, Port-a-Kamp, and National Homes, the obvious difficulties of working overseas appear to have discouraged U.S. firms. A number of medium-sized panelized and modular manufacturers have been approached regarding the export of building systems during the past 10 years, but they have declined to participate. Typical reasons given include:

- unfamiliarity with market requirements, international business law, and payment conventions;
- the uncertain political climate within many countries, and the difficulty in gaining code approval and binding commitments from appropriate government agencies;
- concerns over the reliability of payments, the frequent use of local currencies, and the difficulty of bringing money out of individual countries;
- the high cost of project development, including the need for overseas personnel who determine realistic opportunities, and the high cost of large-scale proposals;
- low profit margins that arise from the current increase in competition; and
- the belief that other U.S. firms have had trouble penetrating overseas markets, or sustaining profitable operations once the markets were established.

Most American manufacturers have had enough difficulty in coping with the changing nature of the U.S. construction market. Generally, they view the uncertainties of offshore markets—with the possible exceptions of Canada and the Caribbean—with strong misgivings.

Materials Acceptance Problems

Just as foreign materials have to meet U.S. standards, American materials must comply with foreign codes. This may require extensive testing. Not only is this a disincentive for direct export of U.S. products; it may put a U.S. firm at a disadvantage relative to a foreign firm when both wish to export to a third country. Many countries, particularly in Europe, test their materials according to international standards. A foreign firm may have conducted the necessary international testing already.

Building Codes and Inspection Systems

Each country maintains a different code and approval process, which leads to varying approval times. Export success could be facilitated by a better understanding of the complexities of each code, relative to the size of the potential market.

The countries of the European Economic Community plan to adapt interchangeable codes, based on West German building standards. Once this occurs, European firms will not have to understand or comply with a foreign code when they wish to export within Europe, placing the United States at a disadvantage.

Trade Restrictions

The possibility of limitations or quotas on imports to a given country always exists. These restrictions may be direct or indirect; Japanese practices in regulating and testing imports are an example of the latter. Such practices have eliminated potential profits on many products that would fare successfully in an open Japanese market.

Lack of Experience in International Trade

Even firms experienced in foreign trade meet with unanticipated difficulties, due to the customs or laws of particular countries; experience in one country may not help in another. For example, one builder reported that six American trucks were left on a dock in Trinidad when the government, citing the fact that the driver sat on the left side of these vehicles, refused entry. Also, documentation requirements and bureaucracy in a certain country may place an extreme burden on a builder.

International Volatility

Much of the demand for housing is in politically and economically volatile parts of the world. Projects are at the mercy of economic disruptions, such as oil embargo and its resulting price increases, or political disruptions, where the government instability endangers the completion of a project. Iran, Iraq, Libya, Lebanon, and certain South American countries are cases in point. In one instance, a drop in oil prices led to problems in the Venezuelan Government, which in turn became unable to provide U.S. builders with enough support to continue with a large-scale housing project. The involved firms lost a substantial amount of project development costs.

Corruption

Payoffs and kickbacks are an accepted part of business in many parts of the world. U.S. companies have withdrawn from such practices, due to the 1971 Foreign Corrupt Trade Act. Although some U.S. firms may avoid these strictures by joint venturing, or by using agents to distance themselves from such transactions, much work has been taken by manufacturers whose governments tolerate or condone bribery.

Distance

Some U.S. firms will operate in North and Central America, but view the rest of the world as too far away. Also, the traditional American disregard for foreign practices, customs, and ways of doing business may make American firms less willing to enter an alien culture.

Lack of U.S. Government Support

The U.S. Government provides less support for housing manufacturers than do other governments. Few prospects exist for the development of imaginative financing programs, performance bonding support, or profitability support.

INCENTIVES AND OPPORTUNITIES FOR U.S. PENETRATION OF OVERSEAS MARKETS

Incentives for U.S. firms to penetrate foreign markets are limited. While large markets do provide American companies with the opportunity to export industrialized housing, the cost-effectiveness of such actions would be negative within current economic parameters. Given the incentives and disincentives listed above, some conclusions may be drawn about increasing U.S. exports in the building industry.

Exportation of Materials

The expanding Japanese market for 2 by 4 construction represents an obvious area of opportunity for U.S. exporters. Japan is the largest importer of wood from the United States and Canada, and accounts for about 30 percent of American wood exports. Primarily, this wood serves the traditional Japanese wood-framed building, which takes up most of Japan's housing construction. Industrialized housing constitutes only 15 percent of the market. It has not yet displaced traditional building.

The 2 by 4 frame method of construction, which accounts for less than 10 percent of the Japanese housing market, is a growing alternative to both conventional and factory-built housing. This may increase demand for wood products from the United

States, and for American machines that fabricate 2 by 4 panels. Daiwa, one of the five largest Japanese home manufacturers, has studied U.S. factory production techniques utilizing 2 by 4 construction. This may indicate that 2 by 4 panels will replace the current Japanese wood panel, which employs a wooden lattice composed of smaller wood members.

Marketing Strategies

Package deals incorporating housing and financing may stimulate exports of building systems. Given the current state of the international economy and the lack of funds available for building, many projects are assigned based on what company can obtain the most-favorable financing arrangements. In this situation, a strong dollar benefits U.S. firms.

Possible New Incentives for Trade by the U.S. Government

The U.S. Exim (Export-Import) Bank does not finance housing, except as part of larger overall development. In contrast, foreign export-import banks sponsor housing projects from their own countries with loans that are 2 to 3 percent lower than those of the Exim Bank. In light of the recent budget reductions for the Exim Bank and of its decreasing role, assistance from this source may not arrive soon. Currently, opportunities exist for projects in Iran, Iraq, and the Soviet Union, but European and Japanese firms have significant leverage due to government willingness to provide financing. The French are financing housing in Sudan at 4.5 percent, with a 5-year moratorium on payment.

The U.S. Agency for International Development may finance American construction overseas, through sending American building systems as aid to Third World nations instead of direct financial aid. This would resemble the European practice of delivering aid in the form of domestic goods.

Chapter 6

Government's Role in Facilitating New Technology

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FACTORS IMPEDING INNOVATION

U.S. homebuilders have been slow to incorporate state-of-the-art technologies into their production lines for a number of reasons. Without a policy aimed at identifying and removing existing barriers to innovation, they may continue to retard growth in the productivity of this important industry.

The Regulatory Environment

Inconsistent State and local building codes and differing inspection practices are frequently cited obstacles to technological innovation in the U.S. housing construction industry. This regulatory morass prevents manufacturers from achieving the economies of scale needed to justify large investment in sophisticated production facilities. Due to the absence of Federal initiatives in the area, the major codemaking organizations and the homebuilding industry have begun to develop a formal plan of action for an effective national inspection system; details of this consensus State-based proposal will be addressed.[1] The States, of course, argue that control over housing regulation should remain with State and local government.

The General Accounting Office expressed a similar view in its 1982 report, "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs." The report cited "restrictive and inconsistent local building codes" as a major factor impeding "the use of available technological innovations and the development and introduction of new ones."[2] On the other hand, some members of the residential construction industry blame the introduction of the national HUD code system for the sharp drop in "manufactured" (mobile) home sales.

In addition to the problem of market fragmentation, industry spokespersons cite the time and money demands involved in complying with current codes. As one housing producer asserts, in the absence of a national—or sometimes even a State—code:

> . . . the factory is forced to deal with local building officials at a city, township or county level. The magnitude of effort needed to deal with so many different agencies and people takes company resources and engineering skills away from more productive activities. And most important, the unending local changes to the building codes create unbelievable difficulty on the factory assembly line.[3]

This lack of uniformity adds to the expense of technological innovation, making developers of new products "unable to afford the enormous cost of selling the new technology to numerous regulatory officials."[4] The closest thing to a national approval in the non-"manufactured" (mobile) home industry is the "NER" National Research Board approval. An NER can cost up to $10,000, and has significant limitations. This detailed approval procedure itemizes every aspect of a given technology. Any change requires reevaluation, and adds expense as a result.[5] A number of States refuse to accept NERs "because they do not include follow-up production line inspections or inplant visits of any kind."[6] Eleven States have formed a special task force to certify product approval agencies.

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[1] Council of American Building Officials, News Release, May 1986; and National Association of Home Builders, International Conference of Building Officials, Building Officials and Code Administrators International, Southern Building Code Congress International, Council of American Building Officials, National Conference of States on Building Codes and Standards, "Concept Paper Prepared by the Task Force on Housing," Mar. 25, 1986.

[2] U.S. Congress, General Accounting Office, "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs" (Washington, DC: Comptroller General of the United States, 1982).

[3] Ed Starostovic, "Changes in Manufactured Housing and Construction of Non-Residential Modular Buildings in the United States," unpublished paper prepared for the Office of Technology Assessment, 1985.

[4] Ibid.

[5] Ibid.

[6] National Conference of States on Building Codes and Standards, Inc., May 25, 1986.

America's building codes and enforcement systems may not impede technological innovation directly. They seldom forbid the use of newer materials, components, structural forms, designs or processes; when explicit prohibitions do exist, they are of secondary importance. The real point is that the present system detects technological innovation *indirectly*, by creating market fragmentation.

Inadequate Study of Total Building Systems and Information Dissemination

Unlike Japan and Sweden, the United States does not sponsor extensive research on new housing materials, technologies, systems, or fundamental concepts. Generally, research efforts tend to be short term and related to a specific problem, rather than large-scale, well-publicized projects designed to increase overall productivity. Industry analysts agree that this research gap impedes innovation, and that the lack of institutional and financial research support aggravates the problem.

Fluctuations in the Building Cycle

Unpredictable demand for housing mitigates against capital investment in new technologies. Fluctuations in the building cycle discourage home producers from investing in capital-intensive, highly automated production technologies. In fact, one industry analyst notes that "manufacturers have relied on a highly elastic labor supply in lieu of automation. Large fixed investments in automated and mechanized processing equipment would eliminate much of the flexibility that is so vital to success in a seasonal industry."[7]

On the other hand, other industries have begun to employ systems that manufacture a variety of products; this decreases their dependency on specialized markets. Such flexibility within a sophisticated production system would be preferable, from the worker's perspective, to the current cyclical patterns of layoff, bankruptcy, and startup.

HOUSING REGULATION

The Current Regulatory Framework

Four model building codes form the basis for most U.S. housing regulation, with the exception of HUD-regulated "manufactured" housing (mobile homes). The model codes are developed by the International Conference of Building Officials (ICBO), Building Officials and Code Administrators International, Inc. (BOCA), Southern Building Code Congress International, Inc. (SBCCI), and the umbrella organization, the Council of American Building Officials (CABO). These organizations enjoy a broad-based membership, including both regulatory officials and a variety of private sector building and construction professionals. This membership plays a significant role in maintaining responsive, consensus-oriented codes that serve the public interest.

Each model code group publishes a building code, a plumbing code, a mechanical code, a fire prevention code, and other such documents. These codes correspond to the model code package, to avoid conflicting requirements for the same condition. New editions of the code appear periodically, in 3-year cycles. The membership conducts annual code change hearings, voting on amendments to the current edition of the code. The approved amendments enter the next edition of the code.

Each model code tends to be regional. Although certain States have adopted one model code exclusively, some overlap exists. The prevailing regional patterns are: the Uniform Building Code (UBC), promulgated by ICBO and used west of the Mississippi; the BOCA Basic/National Building Code, promulgated by BOCA and used throughout the Northeast and Midwest; and the Standard Building Code, promulgated by SBCCI and used in the South. CABO oversees the three. Currently, local governments apply several thousand major and minor variations of these basic codes. There are at least as many inspection systems, with differences in building code interpretations and varying degrees of enforcement. The various fire safety codes and inspection systems that relate to buildings compound this regulatory complexity.

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[7] Arthur D. Bernhardt, *Building Tomorrow: The Mobile/Manufactured Housing Industry* (Cambridge, MA: The MIT Press, 1980).

Thirty-four States have adopted preemptive State codes for modular housing. Those codes cover component housing systems, including panelized homes in 28 States, large components such as "wet cores" in 31, and precut houses in 6. While these preemptive codes reflect significant efforts by States to consolidate codes for industrialized housing, they have not eliminated the problems of diversity and complexity. Twenty-five States prescribe mandatory minimum standards, 7 establish mandatory maximums, and 11 set both mandatory minimums and maximums—"mini-max," or single mandatory codes. Two of the preemptive State codes are mandatory unless specified otherwise. In one State, a local political jurisdiction may amend the mandatory State code with State approval.

Enforcement systems also vary, both among and within States. Inspections are conducted by State officials in 31 States, by county officials in 8, and by municipal officials in 13. Twenty-three States allow inspections by third-party private firms. Omitted from these figures are the 16 States that do not have building codes for any type of factory-built housing.

This complex regulatory system poses formidable problems for large U.S. homebuilders. The producer must satisfy hundreds, if not thousands, of building codes and inspection systems in order to serve the national market and still abide by the law. Disparities between State transportation codes governing large trucks add to the confusion. A spokesperson from the National Association of Home Builders estimates that a uniform code for modular and panelized homes would reduce costs by 3 to 5 percent.[8]

Producers of modular and panelized homes face other problems. Because the walls of some of these building systems are closed at the factory, certain features cannot be inspected at the final building site. Instead, they must be examined at the factory, which may be located far from the site. These factory inspections replace a significant part of the onsite work that is traditionally done by government building inspectors.

A number of communities around the Nation create de facto building regulation through zoning and other local codes. Zoning can be employed in ways that "exclude people from the community,"[9] such as confining "manufactured" (mobile) homes to "trailer parks" in disadvantaged locations, or requiring significant lot or house sizes.

As a result of this situation, U.S. housing producers have been slow to introduce either innovative housing designs or advanced production technologies.

The HUD Code System

The HUD regulatory system for "manufactured" (mobile) homes represents the only uniform national building code and enforcement system for factory-produced housing.[10] Consequently, this 10-year-old "HUD code," which replaced and adopted large sections of an earlier voluntary code system developed by the industry, serves as a model against which others may be measured.[11]

Due to the establishment of this system, a uniform national building code for "manufactured" (mobile) homes now exists throughout the United States. Approximately 400 manufacturing plants in 24 States are currently inspected by a system that involves State agencies, third-party private inspection firms, a national monitoring contractor, and HUD. HUD administers the program with a small staff of Federal employees, at minimal cost to the Federal Government. Covering the program's cost are inspection fees—up to $75 per transportable unit—paid for by the manufacturers, and ultimately by customers.

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[8] General Accounting Office, op. cit.

[9] Stephen Seidel, "Housing Costs and Regulations: Confronting the Regulatory Maze" (New Burnswick, NJ: Center for Urban Policy Research, 1978), p. 174.

[10] The Minimum Property Standards for One and Two Family Dwellings, used to approve federally guaranteed mortgages and in other Federal housing programs, is another type of national building code and enforcement system, administered by HUD. This system has existed since the 1930s, much longer than the HUD code system for "manufactured" (mobile) homes. However, this system relies heavily on other codes and enforcement systems. It was not designed to address the unique problems of factory-produced housing, especially on the inspection side, nor did it replace other building codes and inspection systems of the same buildings. Until recently, it included some features of building codes, but also included site and building designs, and other acceptability criteria not usually covered in building codes. Also, the Federal dimension of the Act has been weakened by recent legislation that allows for the substitution of functional State and local codes for national standards.

[11] Bernhardt, op. cit.

Problems of the HUD Code System

Congress will need to examine the HUD code system if alternative regulatory schemes for factory-built housing are to be considered. Various problems that surround today's HUD code homes may become more pronounced if this regulatory scheme is "stretched" to cover other categories of manufactured buildings, or to serve higher income markets where owners may be more critical.

The Potential for a Conflict of Interest.—The existing HUD code system creates the appearance of a conflict of interest on the part of design and construction inspectors, since fees and services are negotiated directly between manufacturers and HUD-approved private firms. The housing manufacturers themselves hire both the third-party firms that assess home designs against HUD code standards—Design Approval Primary Inspection Agencies (DAPIAs)—and those firms that conduct in-plant inspections during the construction of approved designs—Production Inspection Primary Inspection Agencies (IPIAs). The manufacturer pays these firms, and also has sole discretion over future rehiring decisions. Currently, 8 private firms do over 90 percent of the design approval work, and about 35 percent of the in-plant inspections, for the Nation's "manufactured" (mobile) homes. State government agencies, acting as exclusive inspectors, conduct the remaining design approvals and in-plant inspections, which has given rise to other problems.[12]

PIAs must meet rigid HUD criteria to avoid conflicts of interest, but whether HUD can ensure that these criteria will continue to be met is uncertain. Some members of the "manufactured" (mobile) home industry would like to modify the existing system by eliminating the exclusive right of States to act as IPIAs. At the same time, they would like to maintain Federal preemption of State and local codes that, in many cases, are more stringent than the Federal standards. If Congress wishes to ensure effective national regulation of the industry, HUD's statutory authority in these areas will need to be strengthened and made more consistent.

While there are similarities between the functions served by IPIAs and certified public accountants, IPIAs are not subject to many of the certification requirements faced by CPAs. Both are charged with serving the public interest; however, CPAs—unlike IPIAs—are subject to rigorous preliminary examinations, as well as to professional and State regulation. The threat of removing a CPA's certification provides the public with protection against default.

It is important to note that the concept "potential for a conflict of interest" is used to avoid the need to prove impropriety. Certain public individuals must not only be above criminal behavior, but should avoid situations where the public trust and confidence would be shaken by even the possibility of illicit financial considerations. For example, judges cannot vote on cases when they own stock in a corporation that is before the court, even if there is no suggestion of individual venality. The IPIA/DAPIA system, however, does not guarantee that a conflict will not arise; for example, the system allows a regulated party to discharge an inspection agency.

Various administrative remedies may reduce the incentives for abuse. HUD, rather than the manufacturer, could set and collect inspection fees. Manufacturers and private inspection firms could be required to sign 2- or 3-year contracts for services, giving the firms more independence from their employers. Firms might be permitted to do engineering design and drawings, or design approvals, or in-plant inspections, but not all three. The Federal enforcement agency could assign Federal inspectors, or select private inspection firms, in cases where monitoring indicated frequent violations of minimum standards. As matters now stand, only IPIA's have the authority to pull Federal labels for noncompliance with HUD standards; the government can act only to counter an imminent safety hazard. Technically, HUD can inform the IPIA or the manufacturer that a unit failed to conform with a code requirement, but whether steps have been taken to use this authority in a meaningful way has not been demonstrated.

This is not to suggest that private firms cannot perform responsible inspections; the advantages of nongovernmental inspection systems will be discussed later in this report. Nevertheless, the potential for a conflict of interest is built into the present system. Existing monitoring and enforcement practices provide insufficient protections against the potential for abuse. The steps described above suggest some ways in which enforcement might be improved.

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[12] U.S. Department of Housing and Urban Development, *Fifth Report to Congress on the Manufactured Housing Program* (p. 51) illustrates performance problems of State agencies and private firms through 1982. Although HUD has not yet published data for subsequent years, other information indicates continuing problems as well as improvements since that time.

Responsibility for Compliance With Codes.—The HUD code system clouds responsibility for compliance with national standards. The regulations do not require that the consumer be notified as to whether the "manufactured" (mobile) home complies with the standards. The manufacturer must certify to the dealer or distributor that the structures meet the code,[13] but the approved label for retail units provides no such assurance. This consumer label states:

> As evidenced by this label No. ABC 000 001, the manufacturer certifies to the best of the manufacturer's knowledge and belief that this manufactured home has been inspected in accordance with requirements of the Department of Housing and Urban Development and is constructed in conformance with the Federal Manufactured Home Construction and Safety Standards in effect on the date of manufacture.[14]

The label certifies inspection, but not compliance beyond a good-faith effort.

Homebuyers have limited recourse without an express guarantee. In fact, certain State laws may be of no help to the consumer, since the manufacturer may avoid State regulations in excess of Federal statutory requirements. While consumers may pursue remedies involving repair of minor defects, the legal framework seems to prevent States from acting on their behalf, which would constitute an alternative regulatory structure.

HUD does not permit "false" advertising, which would imply HUD endorsement of a "manufactured" (mobile) home. Indeed, HUD has issued a categorical denial of responsibility:

> Any assertion that the Department directly or indirectly approves the construction or sale of any mobile home or that the Department inspects mobile homes is false, except in the rare case where a mobile home has actually been inspected by an employee of the Department. Even in those cases the Department has not approved the home.[15]

The recent Varig Airline case confirms that under HUD regulations, the Department cannot be held responsible for failure to ensure proper inspection.

Failure To Require Full Compliance With All Standards.—HUD regulations and enforcement mechanisms also fail to assure that every home complies with all HUD code standards. The present HUD code system requires inspections by State agencies or third-party private firms of a sampling of homes in a manufacturer's production line. Each home is inspected in at least one stage of production, and the number of production stages varies; the current Acceptable Quality Level (AQL) list includes 174 inspection items. Furthermore, HUD has not prescribed uniform test procedures to assure compliance with its performance standards.

Complete data have not been compiled on noncompliances with HUD standards. However, HUD's contractor, the National Conference of States on Building Codes and Standards (NCSBCS), conducts monitoring inspections of each manufacturing plant at least twice a year. These inspections aim at evaluating the manufacturers' internal quality control systems, as well as the performance of State agencies and third-party private firms that do in-plant inspections.

Although not intended for this purpose, the NCSBCS data developed from these semiannual inspections suggest the frequency of noncompliance of all units produced in HUD-inspected factories. Manufacturers often learn of NCSBCS visits in advance, and prepare accordingly; as a result, nonconformance identified through such inspections may underestimate the actual figure. Data provided to OTA by HUD for December 1984 through May 1985 indicate that most homes produced during that period failed to conform to one or more AQL items, averaging 3.6 nonconformances per inspection (see table 13). Another breakdown of NCSBCS data, for November 1984 through March 1985, indicates that 8 percent of all nonconformances related to AQL items in planning and fire safety, 55.5 percent to construction, 16.9 to electrical items, 11.3 percent to thermal items, and 8.1 percent to plumbing items.

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[13] Section 616 of the National Manufactured Housing Construction and Safety Standards Act states:

> Every manufacturer of manufactured homes shall furnish to the distributor or dealer at the time of delivery of each such manufactured home produced by such manufacturer certification that such manufactured home conforms to all applicable Federal Construction and Safety Standards.

[14] 3282.362(c)2(c), p. 253.

[15] U.S. Department of Housing and Urban Development, *Fourth Annual Report to the Congress on Mobile Homes.*

Table 13.—Compliance With Acceptable Quality List (December 1984-May 1985)

Percent of AQL items in compliance	Percent of units in the specified compliance range
95-100	30.1
90-95	30.1
85-90	23.6
80-85	9.8
<80	6.5

SOURCE: U.S. Department of Housing and Urban Development.

Although this record appears to be poor, the present HUD code system does protect the public from "imminent safety hazards" that present "imminent and unreasonable risk of death or serious injury"; it does guard against major defects which occur when a series of homes exits the production line; and it does initiate a consumer complaint process, operated by HUD and by State administrative agencies who can respond without Federal enforcement authority.

However, the Federal system provides limited protection for the individual purchaser whose home fails to comply with the standards. HUD addresses consumer complaints from States that have not established administrative agencies for the HUD "manufactured" (mobile) home program. Although the purchaser may go to the courts, he bears both the expenses of this action and the burden of proof. Except for health and safety problems, such as formaldehyde emissions from plywood and particleboard materials, court action has little use or effect in the present HUD code system. Furthermore, most HUD code "manufactured" (mobile) homes are sold to lower income purchasers, who tend to avoid the costs of litigation.

The experience of the HUD code system raises questions that may affect the formulation of industrywide regulations for all categories of residential construction. Even the existing HUD regulations may need review, in light of newly available information; although HUD's data for estimating nonconformances in production, and for evaluating regulatory performance, need improvement, Department statistics do indicate a number of important issues. For example, production defects can now be detected, counted, and reported. What levels of quality, what standards, and what degrees of conformance should be considered acceptable? How should the regulatory system employ the data for enforcement? Should factory production involve inspection of production lines rather than of individual units, as is done for site-built housing?

Weakness of Remedies and Penalties for Noncompliance.—HUD may lack the legal authority to enforce full compliance with certain code standards. Under HUD regulations: "A manufacturer . . . shall correct, at its expense, any imminent safety hazard or serious defect that can be related to an error in design or assembly of the manufactured home."[16] HUD has interpreted this congressional enabling legislation to mean that it cannot require manufacturers to bring defective homes into code compliance, unless "unreasonable risk of injury or death" exists. According to this interpretation, questions of durability, quality, and amenity remain outside HUD's jurisdiction. On the other hand, the HUD code's "Statement of Purpose" calls upon HUD to improve the quality and durability of manufactured homes.[17] Federal legislation may be needed to resolve this double standard.

Formal rulemaking guidelines dictate attempts to increase inspections, and steps to disqualify Primary Inspection Agencies for improper or insufficient inspections—or for improper awarding of Federal labels—are complex and protracted. Moreover, under the preemption section of the statute,[18] States may not enforce the Federal construction and safety standards more stringently than the Federal Government. Still, some States have used their business licensing or registration laws to enforce the HUD code standards when HUD has failed to require compliance.

Inadequate Provisions for After-Factory Inspections.—The present HUD code system emphasizes in-plant inspections, an important area of code enforcement for all types of industrialized housing. However, the present HUD code system lacks an efficient framework for after-factory inspections. Through no fault of either the manufacturer or the manufacturing process, many "manufactured" (mobile) homes with Federal labels fail to meet HUD standards on arrival at their final destination. Units may be altered or damaged at dealerships, where they are stored and shown to customers; or, the rigors of transportation from factories to dealer lots and from dealer lots to final building sites may decrease quality, especially when units are transported along uneven country roads. The problem of "torque," or the twisting of the entire unit, can arise if the home does not rest on a level foundation at the final site. "Tie-downs" to foundations, connections between double-wides or multiple units, and utility hook-ups pose additional problems at the building site.

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[16] 3282.406.

[17] Title VI, Section 602.

[18] 3282.11.

The after-factory inspection process depends on State and local regulatory systems. Under HUD regulations, dealers may not sell units that have failed to meet HUD code standards. However, many State and local agencies do not conduct visual inspections of units on dealer or buyer lots; when inspections are made, reporting and followup are minimal. NCSBCS has developed a voluntary consensus standard for "siting" of units, but although CABO and NCSBCS have developed code language for this purpose[19]—which may or may not be used—a Federal onsite system of inspections or enforcement does not exist.

Lack of Incentives for Improving Durability and Quality.—The HUD code program was designed to improve durability and quality, along with safety. While the safety record of "manufactured" (mobile) homes has improved, it is still less than that of site-built housing; also, it is difficult to show that durability and quality have been addressed. Furthermore, while some manufacturers satisfy HUD code standards with ease, the regulatory system for "manufactured" (mobile) homes does not recognize differences in quality. As a result, many producers build down to minimum safety, rather than up to minimum quality standards.

The implications of this extend to energy costs, which are higher in HUD code homes than in those that satisfy the requirements of Title V of the Farmers Home Administration (FmHA). A recent study conducted for the Department of Energy revealed that if FmHA energy standards were used instead of HUD's Title V standards, energy consumption of most units would be reduced by 37 to 46 percent. HUD's own Title II-E standards, which apply only to "manufactured" (mobile) homes on a permanent foundation, would improve energy performance by 4 to 23 percent.[20]

A proposal to establish quality grades within categories of industrialized housing offers a solution to this problem, and will be addressed in this report. The marketplace, rather than market advantages created by government regulations, would then determine the levels of quality that home producers could offer to informed or affluent customers.

The Role of Federal Oversight.—In general, the "manufactured" (mobile) housing industry supports the preemptive Federal standards that currently guide all U.S. "manufactured" (mobile) homes, while HUD would like to grant more control to the marketplace, and to State and local standards. Also, HUD and the industry have differing views on enforcement procedures; many industry representatives would like to see less Federal oversight, as well as the elimination of the States' right to act as exclusive inspection agencies. Many States, however, have expressed concern over proper levels of inspection, and worry that a weakening of the preemptive Federal system could aggravate problems.[21] The States have assumed some blame for the present situation; they are now developing recommendations on how to improve the State role in national housing regulation reforms.[22]

Criteria for a New Regulatory System

The following sections of this report suggest possible alternatives to the present system of housing regulation in the United States. First, however, a set of criteria is presented, against which such proposals could be judged. Throughout the discussion, the phrase "a national system of building codes and inspections" is used generically to imply a high degree of national consolidation and organization. A national system may be legislated or operated by the Federal Government, by State or local governments, or with the regulatory participation of third-party private firms. It may be a single consolidated system for the entire country, or a national organization comprised of subsystems for different types of manufactured buildings, for manufactured buildings that meet certain criteria, for different code-setting or inspection functions, or for different multi-State geographic regions.

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[19] NCSBCS, May 1986, op. cit.

[20] Pacific Northwest Laboratory, "Impacts of Alternative Residential Energy Standards," November 1985, p. 9.2.

[21] Combined Meeting of the NCSBCS Regulatory Affairs Committee, State Manufactured Building Administrators, and State Building Officials Subcommittees, Arlington, VA, Apr. 23, 1986.

[22] NCSBCS, May 1986, op. cit.

In order to remove regulatory impediments to residential construction and its related industries, a modified national code and inspection system might be evaluated against the following criteria:

1. *Does the system apply to all categories of industrialized housing and modular nonresidential buildings?* Those buildings that contain closed components, factory-made to fit and function together, could be emphasized.
2. *Does the system facilitate market aggregation?* Under a relatively uniform framework, firms may anticipate the codes and enforcement systems that factory-built homes must satisfy within a large geographic area. Uniformity would also enable manufacturers to achieve economies of scale from factory production-line systems. Ideally, with appropriate adjustments for climatic and other features, such as energy requirements, wind and snow loads, and seismic requirements, a unit produced anywhere in the United States could be used nationwide.
3. *Does the system include reliable and consistent enforcement, to protect manufacturers, dealers, and contractors from subjective or arbitrary interpretations of codes?* This would protect the public from the consequences of code violations.
4. *Does the system reduce costs and administrative burdens associated with regulation?*
5. *Does the system leave as much control as possible in the hands of local regulatory authorities?* Regional or national codes need not undermine well-designed State or local codes. Instead, the new regulatory mechanism could be built on successful State and local experiences.
6. *Does the system constitute part of a coherent housing policy that provides Americans with the highest quality at the lowest cost?* This would require programs that protect consumers while encouraging industrial innovation and entrepreneurship.

Alternative Regulatory Systems

Historically, the writing and enforcement of building codes in the United States have been performed by the same unit of government. In contrast, the very nature of industrialized housing invites a separation of these functions. How and by whom codes are written may differ from where and by whom codes are enforced. Moreover, although the codes themselves have received the most attention—resulting in four national model codes—the Nation's fragmented code enforcement system poses a larger impediment to the development of the industry. Consequently, initial alternatives for a national system relate to the enforcement function.

Local factors also enter into play. Until the 20th century, most housing construction was a function of commerce within States. Traditionally, Congress has deferred to State, county, and municipal desires in such matters. As a result of technological developments in recent years, housing has entered the realm of interstate commerce. Some industry experts believe that a Federal system would bring the regulatory function in line with the current residential construction process. On the other hand, this would tend to dilute local control, and might provoke opposition from State and local building officials and their related constituencies.

The following discussion describes four categories of alternatives: systems in which the Federal Government has lead role; in which the State Government has lead role; in which private organizations have the lead role; or cross-cutting strategies, which may combine all or any of the three. These alternatives do not represent complete or detailed designs of regulatory systems. Rather, they should be viewed as generic possibilities, which hold the potential to develop new systems.

Systems Administered by the Federal Government

An Expanded HUD Code System.—The HUD code system might be expanded in its present form, making it a federally preemptive, national system that would cover other categories of industrialized housing and related nonresidential modular buildings. This would require congressional legislation.

Under this alternative, the system could grow stronger through legislative or administrative modifications. Along these lines, the NCSBCS has developed an improved system of quality control and compliance evaluation for HUD, in consultation with industry representatives; the system is now in review. These and other administrative steps may improve compliance with the HUD code for durability and quality features of "manufactured" (mobile) homes.

Alternatives to HUD Code Regulation.—The present HUD code system could be enlarged to cover other categories of industrialized housing and related nonresidential modular buildings, but would be altered in one or all of the following ways:

- Congress might create an independent Federal commission, board, or administrative agency to regulate manufactured buildings covered by the Federal system, replacing HUD's responsibilities in this area. Or, HUD's regulatory functions might be assigned to another existing agency. In either case, HUD would retain the broader responsibilities for affordable housing and would participate in code setting, but would not supervise code enforcement.

  It is difficult for any Federal agency to regulate its own constituency. At present, HUD encourages construction of minimum purchase-price housing, and regulates construction—which may mean increasing housing costs. This alternative would separate the developmental and regulatory functions in residential construction, making it similar to the areas of nuclear power, transportation, and environmental protection.[23]
- A Federal system might preempt State and local regulations for all industrialized housing and related construction, but could be limited in several ways. The system could cover all factory-built homes and related nonresidential modular units that are shipped across State lines, removing impediments to interstate commerce. Or, such a system might include only integral manufactured building systems with closed construction, such as HUD code "manufactured" (mobile) homes; certain modular homes, commercial modular buildings, or panel systems; or large closed components such as "wet cores" —all of these products must be inspected in the factory. State or local governments would still conduct onsite inspection of factory-made buildings when the site and the factory are in the same State, for "open" manufactured building systems and for large "open" components.

  A recent proposal for Federal regulation of appliances, supported by both appliance manufacturers and environmental groups, illustrates this principle. The proposal calls for certain Federal standards to preempt several State and local guidelines, creating a more uniform code system that would benefit both producers and consumers.
- In order to ensure the successful implementation of any alternative to HUD code regulation, Congress might strengthen the language of the statute that guides the present system. A federally based system for all categories of industrialized housing could foster technological research and development by guaranteeing consistency in Federal standards.

  For example, the statutes could specify HUD's role concerning energy standards. HUD is now in the process of amending the code's thermal energy requirements. These guidelines were introduced by HUD, and may soon undergo HUD-initiated changes, even though the original statute did not give specific regulatory authority over energy to the Department.

Incentive Systems.—The Federal Government might adopt a "carrot and stick" approach to encourage States to establish a uniform national code. Such a nonregulatory incentive system for industrialized housing and related nonresidential construction could rely on Federal financing or mortgage guarantees, direct funding to State or local governments, government purchasing, or tax incentives. The incentives need not be new or special subsidies, but could be based on contingent approvals that would allow participation in existing Federal programs. The Federal Government already operates numerous programs that benefit homebuilding, especially those that guarantee or supply credit through the Federal Housing Administration, Veterans Administration, Farmers Home Administration, Government National Mortgage Association, and other such agencies.

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[23] Responsibilities for promoting and regulating nuclear power are vided between the Department of Energy, and the independent Nuear Regulatory Commission; responsibilities in the field of transportion are divided between the Department of Transportation, and the dependent National Transportation Safety Board; and environmental sponsibilities are divided between the Departments of Energy and mmerce, and the Environmental Protection Agency.

The HUD-administered Community Development Block Grant program could serve as another nonregulatory incentive. Builders might qualify for grants only if their homes satisified quality standards established by an organization like NCSBCs. This option would also encourage States to adopt standards that resemble a national code, so that their home industries could qualify for Block Grant funds.

Sweden maintains a particularly effective incentive system. Only those homes that meet stringent performance standards are eligible for the Swedish equivalent of FHA or VA housing subsidies. As a result, the performance characteristics of most new homes exceed those prescribed by statute, especially with respect to energy. This system created such high levels of thermal performance that energy standards could be increased without affecting most construction methods.

These incentives, combined with reliable inspection systems, might persuade State and local governments to bring their codes for manufactured buildings in line with a single, national model code, and they might convince State and local governments to accept industrialized housing and related nonresidential modular buildings produced and inspected in other governmental jurisdictions. This would tend to encourage capital-intensive research, since companies would not have to satisfy a myriad of local codes in order to introduce new technologies to several parts of the country.

The underlying principle exists in two current Federal programs. The interstate highway program transfers funds to the States, contingent on their compliance with federally accepted roadway standards, and conditions like the 55 miles-per-hour speed limit and the 21-year-old minimum drinking age. And the Minimum Property Standards (MPS), administered by HUD, constitute a powerful nonregulatory incentive system; mortgage approvals depend on conformance with certain standards. This ties improvements in technology to the financing process, although other HUD-approved regulation tends to negate such a connection.[24] Also, many previous Federal programs have transferred funds to State and local governments, subject to specific requirements and conditions.

Voluntary Systems.—Under this alternative, manufacturers could select between making their housing subject to Federal approval under a Federal preemptive system, to otherwise applicable State or local government regulations, or to a combination of the two, depending on the type of housing involved.

The Nation's banking system illustrates the principle behind this alternative. The Federal Reserve System gives banks the choice of being either federally or State-chartered, subject to different requirements and regulations. Savings and loan associations may also take advantage of this option.

The present HUD code system operates in a similar manner, although the advantages offered by Federal approval make it impractical for manufacturers to have the "manufactured" (mobile) homes inspected at the State or local level. Producers of both HUD code "manufactured" (mobile) homes and modular homes better illustrate the idea of choice. The latter now fall under State or local regulations. With the "choice alternative" in force, a manufacturer could select the code and enforcement system that best corresponds to the structure being built.

Currently, the Federal Government confers competitive economic advantages to building manufacturers by preempting State and local government regulations—primarily because of benefits stemming from market aggregation. Given these advantages, and the potential advantages of a Federal inspection label for factory-built homes, the Federal Government might set and enforce high-quality standards. This could encourage industry development under a manufacturers' choice alternative.

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[24] In response to complaints of unfair competition from private sector certification groups, HUD has instituted a fee for certification of new technology in its "Technical Suitability of Products Program." Although HUD's charges remain lower than those of the private sector organizations, their presence has led to a decrease in the number of innovative construction programs available to the American marketplace, since developers have less incentive to introduce new technologies.

State Government-Based Systems

Three State government-based systems, in which State governments have the leading role, are discussed below. State regulators contacted by NCSBCS "showed fairly equal support for all three systems."[25]

Multi-State Compacts.—Multi-State compacts, or interstate compacts, are congressionally approved agreements among or between States. Congress sets the rules for any such multi-State arrangement, and State legislatures may vote to enter such compacts only with congressional consent. Having joined, a State may withdraw only under rules established by Congress. The regulatory or operating authority of the compact depends on the nature of the congressional mandate. Over 200 multi-State compacts have been enacted in the United States, for such diverse purposes as water allocation, transportation and port development, corrections, education, forest fire protection, health, motor vehicles, radioactive waste disposal, pest control, planning and development, public works, recreational parks, civil defense and disaster, and welfare.

Historically, compacts have been bilateral, regional, and national in scope. Until the 1920s, most were agreements between two States. The next generation of compacts dealt with regional problems, such as the Colorado River Compact that embraced seven States. The first national agreement was the Interstate Compact for Supervision of Parolees and Probationers, established during the 1930s. Functional compacts, or multilateral agreements that did not rely on regional identification, developed in the 1930s as well; the Interstate Compact to Conserve Oil and Gas was open to all oil-producing States. Compacts also began to serve regulatory purposes; New Jersey and New York enacted the Tri-State Sanitation Compact in 1935 and 1936, respectively, joined by Connecticut in 1941. The Ohio Valley Sanitation Compact represented an early regulatory agreement for a river basin region. Since World War II, the proportion of regional and national compacts has increased relative to bi-State agreements.

Multi-State compacts create a legal regulatory framework between or among States, and employ constitutional powers at both Federal and State levels. They offer two direct advantages to the application of Federal regulatory authority. First, initial State participation is voluntary. Second, while the States give up individual sovereignty for the larger purposes or programs, the agencies that administer such compacts are controlled by the member States. The Federal Government may play a role, but in a subordinate capacity.

Multi-State compacts offer the following advantages for the regulation of industrialized housing:

1. Multi-State compacts would establish reciprocity among States, so that manufactured buildings produced and inspected in one State could be accepted by another.
2. Multi-State compacts could serve as an intermediate preemptive system, superseding the authority of individual States but under the auspices of a federally based preemptive system.
3. Since State codes tend to follow regional groupings, compacts might be created for a limited number of regions across the country. Contiguous or nearby States may reach agreements with one another more easily; most manufactured buildings move regionally, not nationally, because of transportation costs. Also, multi-State compacts might differ according to regional considerations like climatic conditions or market preferences.
4. Multi-State code enforcement for industrialized housing and manufactured commercial buildings might rely on existing State agencies and systems, instead of spawning additional bureaucracy.

The Federal Government might provide incentives for States to join multi-State compacts. Federal financing or mortgage guarantees and other contingent approvals have been described for a nonregulatory Federal incentive system in a previous section. Another kind of incentive involves the Federal Government as an equal partner in the compacts. An enlarged HUD code system, or a modified system of Federal administrative agencies, could have preemptive regulatory authority over manufactured buildings produced in or shipped to States not belonging to multi-State regulatory compacts, encouraging States to join such agreements. In this way, the Federal Government's activities would tend to diminish over time. The Abandoned Mine Reclamation Program illustrates this principle: once a State develops a federally approved program for mine reclamation, it assumes full control of the program.

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[25] NCSBCS, May 1986, op. cit.

Special Regional State Legislation Allowed by Congress.—The recent Supreme Court decision of June 10, 1985, *Northeast Bancorp, Inc., et al. v. Board of Governors of the Federal Reserve System, et al.*, suggests an alternative that resembles the multi-State compact. The court held that since Congress had authorized States to determine what banks could operate within their borders, States were not obliged to accept all banks. The New England States limited approval to regional banks, excluding New York.

The ruling in favor of this policy has important implications for the housing industry. Citing this as precedent, Congress could pass a Federal statute allowing for regional reciprocal cooperation by States in the area of manufactured buildings. This differs from the concept of a multi-State compact, since no regulatory authority would be established.[26] Rather, States would cooperate with one another based on their respective market needs. For example, a State might declare that if other States accepted its own inspection and certification standards, it would respond in kind. This would enable States to limit agreements to nearby "acceptable" States, which hold similar views on codes and code enforcement.

Essentially, such an agreement would represent a lesser form of the multi-State compact in manner, geographic extent, and strength of commitment. However, while this would improve geographic market aggregation by regionalizing the manufactured building industry, it would tend to impede the development of a national system.

Non-Federal Negotiated Agreements.—This alternative involves agreements negotiated between State or local governments, or between a State or local government agency and a private third-party inspector or manufacturer. There is no Federal participation, and agreements need not be accompanied by specific legislation. Such arrangements may be made on a case-by-case basis, and do not require association with a statutory system.

A broad spectrum of formal and informal agreements are covered by this alternative. At one extreme, construction that is not covered by HUD codes—in particular, modular housing and modular nonresidential buildings—could be regulated by ad-hoc arrangements made at the discretion of public officials. State or local governments could agree to accept units that have been produced and inspected in a different jurisdiction. Such negotiated agreements may employ third-party private inspectors, or State inspectors situated close to the factories.

At the other extreme, reciprocal legal arrangements among States for the acceptance of manufactured buildings other than HUD code "manufactured" (mobile) homes can and are now being developed without Federal assistance. Eleven States report some type of agreement with one or more States. Florida, Georgia, and South Carolina will soon conclude a reciprocity agreement, and may be joined by Louisiana, Mississippi, North Carolina, Tennessee, Texas, and Virginia.

Developments within States have facilitated State reciprocity. Many States have begun to confront the problems of manufactured buildings other than HUD code homes, and have consolidated codes and enforcement systems already. Although differences remain both between and within States, 34 different statewide codes preempt local government standards for modular buildings; 28 States have adopted such codes for packaged panelized buildings systems; 31 preempt local standards for large closed components like "wet cores"; and 5 cover precut homes. On the enforcement side, 31 States use State inspectors for manufactured buildings, 21 use county or municipal inspectors, and 23 use third-party inspectors.[27]

In the absence of more complete solutions, negotiated agreements have allowed State and local governments to combat the regulatory problems presented by industrialized housing, especially those relating to factory construction. However, this type of governmental oversight presents problems of consistency, and abuses have been reported. Assuming that the manufactured building industries will continue to enjoy sizable growth, negotiated agreements would be the weakest of all State-based alternatives. Such agreements may be easy to implement, but uniformity over a large multi-State region is difficult to achieve and may not stand the test of time.

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[26] Although Article I, Section 10.1 of the U.S. Constitution holds that "no state shall enter into any treaty, alliance, or confederation" without congressional approval, associations that do not legislate actual regulatory power—as was the case with *Northeast Bancorp*—have been permitted.

[27] NCSBCS, unpublished data.

Proposals of NAHB and the Building Code Associations.—As noted earlier, the National Association of Home Builders, NCSBCS, CABO, BOCA, ICBO, and SBCCI have agreed on principles for a State-based regulatory system that would affect codes and inspection systems throughout the country. They are now in the process of converting these proposals into a formal regulatory system with adequate funding. The system would be based on the following guidelines:

- One of the three major model building codes would be adopted by the States. Local jurisdictions could not make amendments.
- States would enforce the regulations that applied to factory-produced housing, and local jurisdictions would oversee codes for site-built housing.
- The selected model code would be mandatory for all factory-built housing, and for all site-built housing constructed in jurisdictions that use building codes.
- Amendments to the codes would be reviewed "through channels currently used for the model building codes" and "the States would establish a uniform procedure for evaluating and approving new products, design concepts, and construction techniques."
- States would agree to reciprocity agreements for all industrialized buildings.
- Education and training would be provided for builders, building trade workers, and regulatory officials.[28]

Private Responsibility Systems

Private companies and associations play a substantial role in governmental processes for regulating the U.S. housing industry. This participation takes various forms, such as developing consensus standards, establishing model buildings codes, and testing materials.

The American system resembles a gigantic voluntary regulatory scheme, considering the number of private organizations that participate. An estimated 1,800 private American companies manufacture components for homes, and many of these help to develop consensus standards for their products that are later incorporated in building codes. Private firms and industry representatives do much of this work through organizations like the American National Standards Institute and the American Society for Testing and Materials. Industrial trade associations also implement consensus standards, and, as noted, the three major model building codes come from the nongovernmental organizations and CABO.

In addition, numerous profitmaking and nonprofit laboratories test materials, products, and buildings. Underwriters Laboratories, Inc., a private nonprofit firm, occupies a unique position in the industry. The approval of electrical items by Underwriters, or by a laboratory of equal stature, stands as a legal and practical prerequisite for government approval.

Application of Private Regulation.—Private responsibility systems raise questions of accountability: who is responsible, how, and to what extent? Are there any models or examples of effective private responsibility systems that can apply to residential construction, especially in matters of enforcement?

In response to these questions, European systems of private assurance deserve analysis. Belgium has a strong private liability law, under which architects and builders are held responsible for 10 years in matters of building safety and durability. SECO—roughly translated as the "Bureau of Control and Proofing of Building Safety and Construction"—is a nongovernmental engineering consulting organization that tests and inspects all types of structures. Government approvals require SECO inspections; insurance companies also call for SECO inspections as a prerequisite for issuing policies to builders and owners. SECO divides its attention between municipal authorities and the private sector—builders, manufacturers, insurance companies, and building owners. SECO's work includes laboratory testing, reviews of designs and plans, onsite and factory inspections of buildings and components, and plans and reviews of quality control systems. The firm handles approximately 90 percent of all such activities in Belgium, and Belgian courts interpret "good practice" consensus standards developed by SECO. In turn, SECO is legally liable for the advice and approvals that it gives.

Similar systems exist in other countries. In France, several nongovernmental organizations operate like

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[28] CABO News Release, May 1986.

SECO. Local governments or councils in Great Britain and Sweden are legally liable for the inspections made under their auspices. A British law passed in 1984 provides for home liability, and enables the government to accept inspections performed by properly bonded private firms.

More investigation of the effectiveness and problems of European systems is needed. However, these models do suggest possibilities for a "private responsibility" approach in this country, where most government entities have not been legally liable for codes and inspections made under their auspices. Congress might choose to make them liable, in order to make codes and inspections more effective. Under this approach, codes would continue to be set through official government processes, but the enforcement system could be made private in cases of liability transfer. Several ways to implement this approach are described below:

1. Manufacturers' and dealers' warranties could be required on all industrialized housing and nonresidential modular buildings. New Jersey maintains such a mandatory requirement, and several other States are considering the option.
2. Mandatory inspections could be conducted by third-party law firms. The government could license the firms, but payment would come from the various involved parties, following the European model: manufacturers, dealers, contractors, government entities, homeowners, and other building owners. The private inspection firms would issue inspection certificates and affix approval seals that certified full code compliance for manufactured units. Like certified public accountants, they would be bonded and insured as a requirement for licensing, and would be legally liable for their advice on code compliance during inspection.
3. Because they provide liability coverage and building insurance after construction, private insurance companies might become more involved in setting qualifications and requirements. In effect, they would perform a private regulatory function based on risk assessment. Insurance coverage could be required as a matter of law, and companies could set competitive premiums. Currently, U.S. insurance companies engage in loss prevention activities for commercial buildings only; in Switzerland, companies that issue any form of fire insurance require annual inspections and maintenance of heating systems.
4. Private financing institutions, like private insurance companies, could take a more active role in performing a private regulatory function. Compliance with code standards does affect loan risks and marketability of buildings, of obvious importance to private financing institutions. Consequently, in addition to requiring insurance, financing institutions may set specific guidelines for those seeking credit for mortgage financing, or construction loans for manufactured buildings. HUD's Minimum Property Standards, used to approve federally guaranteed mortgages, illustrates this principle.

Cross-Cutting Strategies

A single code for all types of industrialized housing may or may not be technologically realistic or desirable; further study is needed. Alternatives to a single code could accommodate the different categories of housing, and could set grades of housing within categories.

Labeling.—In the United States, appliances are rated for energy efficiency, meats receive quality grade ratings, automobiles are given gasoline mileage ratings, and truck and automobile tires have grade ratings. Housing could adopt a similar system, focusing on health and safety, durability, and quality.

Many existing building regulations mandate "acceptable" minimum health and safety standards. Acceptable minimums indicate the absence of absolute levels, even in health and safety of buildings. For example, differences exist in fire protection—wall materials have distinct interior surface flame spread times, and placement and enclosure of furnaces, number of smoke detectors, number and distance to exits, and exit capacities all differ according to local conditions.

Housing grades may be based on other factors: durability, quality, amenity, and operating or life-cycle costs. HUD has already demonstrated the feasibility of establishing grades through the potential for evaluation of quality, livability, and durability in "manufactured" (mobile) homes.[29]

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[29] U.S. Department of Housing and Urban Development, *Sixth Annual Report to Congress on Manufactured Housing Program*.

There are three approaches to grading homes within categories. First, each key attribute of a house might be rated, with the cumulative result given to the home purchaser. Second, minimum acceptable levels of each attribute might be established for each grade of house. A "Grade A" house would have certain features, a "Grade B" house might be lower, and so on. Third, a house might be graded only for minimum standards of health and safety. Higher grades of homes would carry stickers, demonstrating compliance with selected standards of durability, quality, amenity, and operating or lifecycle costs.

Such improved information about building quality would allow banks to estimate the market value of the structure more accurately. Also, it would permit banks to project potential operating costs, such as energy, for use in qualifying individuals for housing loans. Both features would facilitate the operation of housing markets, and would encourage greater construction quality without prescription.

The establishment of categories of factory-built homes, together with grades within such a system, would yield two important benefits. This market-based solution would allow market forces, and not statutory regulation, to govern supply and demand. Also, it would create incentives for producers to "build up" in order to satisfy better-informed consumers.

Other Models.—Japan maintains national standards for certifying building components. The Japanese Ministry of Construction provides group insurance and a "Better Living" label for housing components that meet specified standards. The Ministry publishes the standards in the Japanese equivalent of the Federal Register, and invites firms to apply for certification. Applications must include detailed design drawings and test results, and are reviewed by a 25-member certification commission composed of consumers, members of "local public organizations," and technical experts in housing components. Certification must be renewed every 3 years.

By June 1985, 541 companies had received certification for 1,417 products in 31 categories. These categories include hot water systems, ventilation units, gas appliances for kitchens, gas leakage alarm systems, solar energy systems, bathtubs, "housing information systems," and even mailboxes, front door units, door locks, window sashes, handrails, interior doors, kitchen cabinets, "master television antennas," and more. Products that carry the "Better Living" label receive two types of insurance: product warranty insurance, which covers costs associated with replacement of a defective component; and product liability insurance, which covers claims resulting from injury or property damage attributable to a failed component.[30]

The French "Agreement" system, where a single national private corporation makes comprehensive technical investigations and certifies building innovations, has been adopted with variations in over 10 countries. The "Agreement" organization assesses likely performance of factors not covered by existing building codes. Its recommendations encompass the design, manufacture, assembly, and installation of products. It also conducts research on testing methods and quality control for manufacturing and building erection procedures.

Dozens of energy rating systems have been developed in the United States. For example, California Utilities began rating new homes in the late 1970s, providing builders with discounts on utility connection charges if their structures met minimum standards of electric energy efficiency. The program succeeded in attracting consumer interest in energy efficiency, but some building officials found the California rating systems "difficult to enforce"[31] due to their relative complexity.

Several other types of systems exist. Austin, Texas, has a "five-star" rating system for new houses. The Western Resources Institute has organized builders, bankers, insurance companies, and realtors into a coalition that provides an "Energy Rated Homes" label for units sold in western Washington; this project is designed to operate by industry consensus, not government intervention.[32] Appraisals leading to a rating are conducted much like standard appraisals.

The State of Florida has combined energy rating with a "minimum standards" approach. New homes, residential additions, or significant renovation must satisfy a minimum standard for energy efficiency, which varies between three "climatic zones"; beyond this threshold, houses receive grades that indicate future performance. However, as with the California Utilities model, effective enforcement has been difficult to achieve, especially in rural areas with low levels of construction.

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[30] Government of Japan, Ministry of Construction, Housing Production Division, *Quality Housing Components Certification System*, 1985.

[31] NCSBCS, May 1986, op. cit.

[32] Jay Luboff, private communication, February 1986.

Presently, California is considering a statewide energy rating system. The California State Building Code mandates stringent energy-efficiency requirements for new homes, which made obsolete the State standards set by the electric utilities and which led to the abandonment of utility-based labeling programs. The California code requires builders to submit certification plans prior to approval. A computer-based analysis then determines whether the proposed structure meets minimum levels of energy performance. Since the computer-based analysis applies to all structures receiving code approval in California, labels with the number of "points" scored can be supplied at no additional cost to the builder. In two demonstration municipalities, the State Energy Commission has established a rating scale for existing residential structures of 1 to 6, where 1 indicates the highest level of energy efficiency. Were this system applied on a statewide level, most existing homes would receive relatively poor scores, illustrating the benefits of purchasing a new home and aiding builders as a result.

Also, banks have been encouraged to consider energy costs when reviewing a borrower's ability to pay. Standard rules call for an owner to pay no more than 28 percent of his or her annual income for principal, interest, taxes, and insurance (PITI), but many lenders have abandoned this standard in the face of skyrocketing housing costs. California loan offices, for example, now allow PITI to reach 32 percent of a buyer's income. If a label allowed lenders to project the energy bills associated with a home purchase, the rules could be extended to include PITI + E, or expected annual energy bills. This would permit lenders and borrowers to integrate operating costs into purchasing decisions with greater accuracy. However, few lenders have moved to consider such quality features as energy efficiency, and the Federal Government has been slow to use its power as a secondary lender to encourage similar considerations. The Federal Home Loan Mortgage Corporation ("Freddie Mac") does account for energy efficiency when a borrower is on the borderline of the PITI equation; the Federal National Mortgage Association ("Fannie Mae") allows for an increase of two percentage points—28 to 30, for example—in the mortage payment-to-debt ratio, if the home satisfies certain energy requirements; other agencies have not yet followed suit. Freddie Mac has indicated that if projected energy costs could be specified with greater accuracy, then the agency would consider including them as a loan determinant.

Other Measures

Four additional options were identified as potentially important, but were not investigated in detail:

1. Mandatory training and examinations for certification of inspectors might be required for all building inspectors. Enhancing the skills and professional qualifications of inspectors will improve code enforcement. The model code agencies and NCSBCS already offer training and examination systems, and 10 States require inspectors of manufactured buildings to take examinations for certification. In fact, most States "strongly endorsed the need for mandatory training and certification examinations for inspector and third-party personnel."[33]
2. Design approvals for manufactured buildings might require reviews and signatures from registered engineers.
3. Improved quality control of factory production-lines for manufactured buildings could be achieved, perhaps borrowing and adapting techniques from other industries.
4. Consumer participation in code-setting for manufactured buildings could be improved, and consumer complaint and appeal processes short of lawsuits could be facilitated.

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[33] NCSBCS, May 1986, op. cit.

FOSTERING TECHNOLOGICAL INNOVATION

Many housing experts urge the U.S. Government to play a more active role in promoting fundamental building research. They claim that without such study, the U.S. residential construction industry will become increasingly vulnerable to foreign competition, and American homebuyers will continue to receive less than their money's worth. The argument concludes that because even the largest housing firms cannot or will not conduct basic research, the Federal Government must make the kind of long-term commitment that has succeeded elsewhere. Sweden's Council for Building Research, for example, spent $39 million on research in 1983, more than three times as much as HUD, despite the fact that Sweden's residential construction industry is approximately one-twentieth the size of its American counterpart. The U.S. Government does support such research in health and agriculture, both of which are based on small establishments that lack the resources to conduct independent research. However, even the 100 large companies that produced 25 percent of all housing units in 1985 did not make significant investments in research. It may be time to reevaluate the historical "laissez-faire" approach to housing research.

Research funds from the private sector, including both individual firms and trade and professional associations, have been inadequate in the past, and a change in this trend seems unlikely. Most large U.S. homebuilding firms do not maintain a research budget, which implies a lack of industry confidence in the cost-effectiveness of technological innovation, at least in the short run. Professional associations of architects and builders, like the American Institute of Architects, conduct some research, but their budgets are minute in relation to the size of the industry as a whole.

Trade associations do sponsor useful research. For example, the NAHB Foundation, Inc., has developed a research house to demonstrate advances in conventional construction techniques, has instituted certification programs for manufacturers of building products, and conducts economic and regulatory analysis for public and private groups. Nevertheless, compared with the resources available to other U.S. industries of a similar size, this construction research program is, at best, limited.

As for public funding, historically small agency budgets have decreased even further. Still, several agencies do sponsor relevant research, including the Department of Agriculture through its Forest Products Laboratory, the Commerce Department through the Centers for Building Technology and Fire Research at the National Bureau of Standards, the Department of Housing and Urban Development, the Department of Energy, the National Science Foundation, and the National Institute of Building Sciences. However, due to poor coordination of these activities, research efforts have remained fragmented and have fallen short of their potential.

HUD has not promoted aggressive policies for basic housing research. A 1982 GAO report states that since 1974, "HUD has funded only one project which demonstrated (in one geographical area) the cumulative cost saving potential of a wide combination of innovative technologies."[34] Some industry representatives assert that HUD's research serves to back up or justify a proposed building regulation, and is seldom made public in any case, although HUD's "Joint Venture on Affordable Housing"—initiated in several cities in 1982—has achieved limited success.

Recognizing the need "to encourage all sectors of the building industry to devise voluntarily a more efficient way of introducing technology into housing and building,"[35] Congress established the National Institute of Building Sciences (NIBS) in 1974. NIBS was designed to spearhead new housing-related research for the industry, a goal that has not yet been achieved. This stems from the specific mandates that accompany NIBS funding, as opposed to funding for the kind of long-term, basic research that enabled Japan to develop its ceramic building material. In 1979, NIBS issued a report that identified "the regulatory environment" as the major constraint on research, development, and demonstration projects. The Institute attributed its own sluggishness to encourage new technologies to a shortage of financial resources.[36]

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[34] General Accounting Office, op. cit.

[35] Public Law 93-383.

[36] "A Study of Existing Processes for the Introduction of New Products and Technology into the Building Industry," prepared by The Ehrenkrantz Group for the National Institute of Building Sciences, 1979.

Summarizing its review of HUD and NIBS as of 1982, the GAO observed that "the statutory authority given to HUD and the National Institute of Building Sciences to encourage the development and use of innovative technology in homebuilding has been receiving only limited attention by HUD and the Institute."[37] Neither agency appears ready to promote research and development of new homebuilding technologies or materials unless funds are earmarked specifically for this purpose.

Preparation of a comprehensive list of priorities would help to increase Federal support for housing-related research. Previous sections of this report have discussed the need to integrate such research into a program that considers the performance of an entire residential structure, in the areas of construction, energy efficiency, safety, and comfort. In light of this situation, a list of research priorities might include the following:[38]

1. *Analytical tools that could facilitate the design of low-cost structures.* For example, most existing computer models for evaluating heating and cooling costs are difficult to use, and are not tied to advanced building design systems. As a result, few architects or builders employ such techniques.
2. *Advanced manufacturing technologies, including a variety of numerically controlled production systems*, which have been developed for other manufacturing industries and could be adapted for use in factory and field housing construction. New standards and communication protocols have accompanied the introduction of these innovations into other sectors, and the residential construction industry may need to repeat this process.
3. *Analytical tools for determining the effect of building design decisions on energy consumption*; present techniques for this purpose are inadequate. Improved estimates for building performance in all types of warm-weather climates are needed. Most existing methods cannot project the effect of different design alternatives on peak electric loads of residences, and energy costs in many southern areas depend more on peak electric loads than on total energy consumption. Also, more efficient analysis of the implications of different window locations, shadings and glazings, patterns of moisture penetration, noise propagation, and heat exchange could be developed.
4. *Simplified and accurate methods of energy labeling, and improved techniques for projecting energy costs.* Financial institutions could employ this data in order to gain a better determination of a borrower's ability to repay a mortgage loan. The present system estimates the principal, interest, taxes, and insurance on a home, and measures this against a borrower's expected annual income; adding projected energy costs would provide for a more accurate equation.
5. *Improved data on the actual performance of different energy efficiency strategies and construction techniques.* Current information on lifetime operating experiences for different systems, especially for residential construction, is poor; maintenance costs of industrialized housing cannot be compared with conventional construction techniques. For example, performance of insulation, sealants, and other materials is not well documented, and the durability of residential retrofits is poorly understood. Differences between the predicted performance of structures and the actual field experience need to be clarified.
6. *Improved techniques for characterizing the performance of residential appliances*, making the estimates of performance for these items match actual field experience with greater accuracy.
7. *Techniques for integrating residential electric systems with utility dispatch systems.* Controls on individual appliances could also be improved.
8. *Technologies of a variety of building components.* Examples include glazing materials, high-efficiency lighting, water heaters with flue-gas condensation, heat-fired—or gas-powered—heat pumps, integrated appliances, and components like compressors and refrigerants.
9. *Controlled interior air quality*, which may become a critical public health issue, particularly

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[37] General Accounting Office, op. cit.

[38] See National Institute of Building Sciences, "Building Technologies Research Agenda: A Technical Report," May 1985; a report entitled "Third Edition of a National Program Plan for the Thermal Performance of Building Envelope Systems and Insulating Materials," Building Thermal Envelope Coordinating Council, is in preparation. See also E. Hirst, et al., *Energy Efficiency in Buildings: Progress & Promise* (Washington, DC: American Council for an Energy Efficient Economy, 1986).

where significant amounts of radon from soil or groundwater have been introduced. Also, more study of interior air pollution is needed —especially of the sources of this factor, and of possible techniques for mitigating its effects.

10. *Industry standards and tests*, which could permit rapid, inexpensive analysis of the performance and safety of new components and systems.

Some industry analysts advocate the creation of a quasi-governmental corporation to test and certify new building technologies for construction. A single approval source for innovations in building technologies could marshal public and private support for innovative development, especially to confront problems of technology transfer. Consensus standards and model code organizations represent existing industries, known product-lines, and current technologies, and tend to resist technological change. Also, because new technologies do not assure certainty in performance characteristics, there is justifiable market resistance to unproven innovations. Homeowners prefer not to gamble with an enormous lifetime investment.

Consequently, one approach calls for existing institutions to continue code setting for older, proven technologies, while a new, quasi-public corporation would test, approve, and promote newer building technologies. Such an institution would serve as a prestigious, unbiased source of information, whose recommendations would be accepted by other institutions.

The Center for Building Technology at the National Bureau of Standards performs a similar function, conducting research for the development of testing standards. The Center acted much like the proposed "quasi-public corporation" in its involvement with Operation Breakthrough. Another example is the relationship between the Federal Food and Drug Administration (FDA) and the National Research Council (NRC) of the National Academy of Sciences. The NRC's independent scientific reviews of pharmaceuticals provide the basis for actions by the FDA.

Stabilizing the Building Cycle

Variable housing construction rates in the United States impede long-term planning and heavy investment in capital equipment and worker training, and discourage long-term technological research. Two million housing units were started in 1978, as opposed to under a million in 1982.[39] Large investments in production equipment can prove financially ruinous during periods of low housing demand, as in the case of U.S. Home (see ch. 2). A strategy for evening the fluctuations in the housing cycle may encourage greater capital investment on the part of the building industry. This discussion does not intend to provide a comprehensive review of this complex but important subject, but several options have been suggested for stimulating short-term housing demand (see box B).[40]

Concerning the potential result of such policies, GAO observed that:

> Past housing stimulus proposals have generally been thought to be inefficient because of a variety of leakages arising from: (1) credit diverted to purposes other than housing; (2) windfalls to sellers; (3) purchases by buyers who receive the subsidy but who would have bought without it at roughly the same time; (4) purchases by buyers who would have bought later but move up their purchases. However, the last group, those who move up their purchase decision, are really doing what a stimulus proposal attempts to do—moving forward consumer decisions to buy at a time when housing is in a slump and reducing demand during the next upswing in the economy. These consumers may also buy more expensive housing than they otherwise would have, which would tend to create more jobs and help the homebuilding industry. Whether or not a stimulus program which would result in moving consumer decisions is desirable depends heavily on the economic outlook. If strong recovery is anticipated it may prove helpful to shift starts forward. If only a weak recovery is anticipated, shifting starts may yield an even weaker recovery. The extent of these leakages have been heavily debated.[41]

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[39] U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States*, 1984, p. 743.

[40] U.S. Congress, General Accounting Office, "Countercyclical Stimulus Proposals for Single-Family Housing," Washington, DC, 1982, pp. 7-8.

[41] Ibid., p. 6.

Box B.—Short-Term Stimulus Proposals for Home Ownership

A. *Temporary Interest Reduction*.—The government could provide interest subsidies during the first 5 years, holding interest to a point below some target rate. Assistance could be limited to low-income households, or to relatively inexpensive housing. Legislation introduced by Senator Richard Lugar would offer subsidies to purchasers of new single-family housing by cutting 1.5 to 4 percent off of mortgage rates if market rates were above 12.5 percent.

B. *Permanent Interest Reduction*.—The government could provide permanent interest subsidies to low-income families for the purchase of new housing. The 1974 Brooke-Cranston Emergency Home Purchase Assistant Act "Tandem," suggested using the Government National Mortgage Association to subsidize interest rates up to 4 percent below any market rates over 11 percent. Sweden supports most new housing in this way. Since the subsidies can only be applied to homes that meet certain standards of quality, this policy encourages quality construction without prescriptive regulation.[42]

C. *Home Buyer Tax Credit*.—Homebuyers, regardless of income, could be made eligible for income tax credits when buying newly built or substantially renovated homes. The credit would equal 5 percent of the purchase price, but would not exceed $5,000. Such a legislation would resemble the Tax Reduction Act of 1975.

D. *Mortgage Interest Tax Credit*.—Mortgage institutions that allocated at least 50 percent of all new investment to housing could receive a Federal income tax credit of 2 percent of their entire mortgage interest income. This would encourage additional mortgage investment.

E. *Tax-Exempt Mortgage Revenue Bonds*.—Homebuyers could finance low-cost mortgages with tax-exempt State and local bonds. However, the 1980 Mortgage Subsidy Bond Act limited the scope of this process. Certain changes might increase demand for interest-free mortgage payments; for example, all homebuyers could be eligible, as opposed to first-time purchases, or the price of eligible housing could increase from 90 to 120 percent of the average area purchase price.

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[42] L. Shipper, A. Meyers, and H. Kelly, *Coming In From the Cold: Energy-Wise Housing in Sweden* (Cabin John, MD: Seven Locks Press, 1985).

Appendix

Appendix

Contributions

This OTA special report was prepared from a variety of sources. Steven Winter of the Steven Winter Associates, Inc., New York, prepared most of the material dealing with international trade. David Dowall of the University of California, Berkeley, and Edward Starostovic, PSF Corp., Wisconsin, contributed to the sections concerning domestic housing production. Robert Gold, OTA, and Vincent Brannigan of the University of Maryland were primarily responsible for the sections addressing policy alternatives; many of these concepts were propsed in a workshop held by OTA (see inside front cover for participants). Janet Lowenthal, OTA contractor, helped to combine the material into an integrated text. Daniel Chenok, OTA, conducted final research, revision, and editing.

Because the information collected by the Steven Winter Associates, Inc., constitutes the basis of chapters 4 and 5 of this special report, it is appropriate to include their statement of methodology:

"In order to present an accurate picture of the state of manufactured housing internationally, and the most important factors affecting it, Steven Winter Associates, Inc., has drawn upon its knowledge of the manufactured housing industry, as well as upon its extensive contacts within the industry.

"Preliminary analysis of the important questions concerning manufactured building internationally determined the most important areas for concentration. Information on these areas was then gathered from a number of sources:

- Steven Winter Associates, Inc.'s files,
- publications—both of the housing industry and more general publications,
- foreign housing manufacturers' literature,
- foreign product manufacturers' literature,
- reports by others, and
- foreign Consulates and Trade Associations.

"In addition, individuals whose knowledge and opinions of the field would be worthwhile were contacted. Due to their positions, many of these individuals requested that their names be kept confidential. Altogether, over 50 persons were contacted, from various fields:

- experts within the manufactured housing industry,
- domestic builders with experience in international markets,
- foreign manufacturers of building systems and their sales representatives,
- building products manufacturers, and
- trade representatives from other countries.

"The information gathered has been compared and analyzed in order to arrive at an understanding of the current state of manufactured housing and its trends. It was beyond the scope of this study to present an exhaustive report on each country considered, although such information will be presented where it is considered important for a basic understanding on the issues. Rather, we have tried to focus on the most important facts and to raise the most important issues, especially concerning those countries that will probably have the greatest role in the international manufactured building market."

Office of Technology Assessment

The Office of Technology Assessment (OTA) was created in 1972 as an analytical arm of Congress. OTA's basic function is to help legislative policymakers anticipate and plan for the consequences of technological changes and to examine the many ways, expected and unexpected, in which technology affects people's lives. The assessment of technology calls for exploration of the physical, biological, economic, social, and political impacts that can result from applications of scientific knowledge. OTA provides Congress with independent and timely information about the potential effects—both beneficial and harmful—of technological applications.

Requests for studies are made by chairmen of standing committees of the House of Representatives or Senate; by the Technology Assessment Board, the governing body of OTA; or by the Director of OTA in consultation with the Board.

The Technology Assessment Board is composed of six members of the House, six members of the Senate, and the OTA Director, who is a non-voting member.

OTA has studies under way in nine program areas: energy and materials; industry, technology, and employment; international security and commerce; biological applications; food and renewable resources; health; communication and information technologies; oceans and environment; and science, education, and transportation.

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